THE

# FOUNDRY TRADE JOURNAL

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## NOTES AND COMMENTS.

### Some Queries Answered.

THE FOUNDRYMEN'S COMPETITION, judging from our correspondence bag, is going to be a huge success. "A Foreman Moulder" writes to ask whether an article dealing with quite a small foundry would come within the terms set out. We can assure our correspondent that a well-designed small foundry would be awarded the THIRTY GUINEA PRIZE in preference to a larger one badly designed.

"Two Foundrymen in Spain" ask whether the fact that they are out of Great Britain will preclude their entering. If they are British subscribers there is absolutely no reason why they should not compete.

There is one point we specially desire to emphasise, that is, practical men stand as good a chance of being successful as a University-trained man, as the latter is always liable to incorporate some error, due to his lack of practical knowledge, which might condemn the whole scheme.

A correspondent, writing under the nom de plume of "Charge-Hand," wishes to know "whether he can collaborate with a friend in the drawing office." We would point out that there is nothing in the rules which we have drawn up which prohibits the collaboration of two individuals.

Naturally, though we cannot undertake to help competitors, we shall at all times be pleased to clear up any doubtful points arising from the wording of the Competition

### Electric Furnaces.

We have recently devoted considerable space in THE FOUNDRY TRADE JOURNAL to the subject of electric furnaces. It was recently stated at a Branch meeting of the Institution of British Foundrymen that the subject was still in its infancy. Whilst not definitely disputing this, it should be pointed out that about 800 electric steel furnaces in the world are producing probably 900,000 tons of ingots and castings per annum.

Recently, enormous progress has been made in the application of the electric furnace to the non-ferrous industries. No less than 261 plants of this type are working in the United States. The more general adoption in this country has been retarded by the non-availability in bulk of suitable current, inadequate floor space, and conservativeness in the industry.

It has recently been stated that the general slump in business has been felt more keenly by electric furnace constructors than by kindred engineering trades. Obviously, present conditions are equally applicable, but are intensified by the unloading of surplus stocks of special steel and the lack of trained operators. This latter condition has been also felt in the United States, and even perhaps more seriously. The question was recently discussed at a special meeting of the Electric Furnace Association, held at Boston. The concluding remarks of the chairman (Mr. A. Acheson Smith) summed up a situation equally applicable to this country. He pointed out that the consensus of opinion of the 22 speakers brought out very prominently that poor electric steel is the result of inefficient operators. The enormous quantities of high grade electric steel successfully marketed conclusively prove that any inferior steel is directly attributable to the personal element. This discussion revealed the fact that metallurgists should be thoroughly familiar with moulding practice as well as steelmaking, as a number of cases have recently come to light where electric steel has been condemned on account of faulty moulding practice. The chairman expressed the opinion that a definite apprenticeship course should be drawn up for melters, in order that the future foundry should be adequately supplied with trained men.

If the case for electric steel has been, or can be, thoroughly established, the time has undoubtedly arrived when this should be energetically taken up by the technical societies and large works of Great Britain.

## THE FOUNDRYMEN'S COMPETITION.

### FIFTY GUINEAS IN PRIZES FOR BEST DESIGN AND EQUIPMENT OF A FOUNDRY.

To mark the change over of the FOUNDRY TRADE JOURNAL from a Monthly to a Weekly publication, the Proprietors have pleasure in announcing that they are offering two Prizes of Thirty and Twenty Guineas respectively for an article dealing with the subject of the design and equipment of a Foundry (ferrous or non-ferrous), with special reference to the latest labour-saving devices and machines, internal transport and handling tackle.

Competitors, by submitting articles, signify that they adhere to the following rules:—

(1) Competitors must be in the employ of an established British foundry subscribing to the FOUNDRY TRADE JOURNAL, or himself a subscriber.

(2) Articles must be illustrated with dimensioned drawings and sketches.

(3) The copyright of all papers and designs accepted for publication will become the property of the Proprietors of the FOUNDRY TRADE JOURNAL.

All papers must reach this office by Thursday, March 3rd, 1921. The decision of the Editor will in all cases be final.

# Correspondence.

To the Editor of THE FOUNDRY TRADE JOURNAL.

"THE CASTINGS TROUBLE."

SIR,—In the December, 1920, issue of THE FOUNDRY TRADE JOURNAL an article bearing the above title appeared. At the first glance one would be led to believe that some certain aspect regarding wasters was to be dealt with, but, upon pursuing the article further, one finds that it is not really something beneficial to foundrymen, although the author seems to have the idea that he is preaching a sermon to that body of men. Although one hesitates to answer "A Buyer," it is essential that his remarks regarding the present position should not pass as being absolutely facts, so far as the majority of foundrymen are concerned, for, without actually accusing, he infers certain items in his article that are far from being facts.

From his point of view, no doubt the position is deplorable, and in lieu of his title of "The Castings Trouble," I suggest that it ought to be entitled "The Buyer's Lament." Undoubtedly, since the iron-founders' strike, foundry affairs have been different from anything previously experienced, insomuch as that they have been absolutely overwhelmed with orders. Naturally they have had to adjust themselves to the new conditions, and have undoubtedly done so with credit. If "A Buyer's" opinion is to be taken for granted, foundries have demanded "alarming" prices, and forced customers to accept indifferent castings. Strong proofs would have to be produced before foundrymen as a whole could accept such a statement. Certainly isolated cases may be found, but "one swallow does not make a summer," and perhaps "A Buyer" has only dealt with a few foundries. A number of his opinions are apt to be misleading if taken for granted. He is living in a fictitious paradise if he believes the events he forecasts will come about.

Chief amongst these is the future position of foundries. In his opinion the time will come when foundrymen generally will be begging for orders, and will be only too pleased to accept any terms that the buyer cares to offer. This was practically the position in 1914. "A Buyer's" idea is that this state of affairs has been brought about by the moulders' strike. This opinion is also held by many people, but by those who are employed inside the industry a different set of reasons are held. The most important of these is that, for a period of years, it has been a well-known fact that a sufficient number of boys have not been apprenticed to the trade, to compensate for men that have left it. In fact, it has been the great worry of founders, who naturally could foresee the time when, owing to the shortage of skilled men, they would not be able to carry on their business to its full capacity. Proof of this is forthcoming by the efforts of the Institution of British Foundrymen in this direction, and the numerous references made at their meetings to this question.

It may be assumed that for the last ten years this has applied, and it would be a favourable figure if one said that only 50 per cent. of the labour requirements had been satisfied. Thus it is easy to discern why foundries cannot adequately deal with abnormal conditions, and it is debatable if they can even satisfy normal ones, or at least be able to do so in the future, as fewer boys than ever are now being apprenticed. The moulders' strike only brought about the climax. The war disguised it to those outside the industry, owing to the absence of trade in cast-iron castings in war time, but even then many foundries were at times pressed to keep up with their deliveries.

"A Buyer" also states that buyers are not having an enviable time, but buyers are worthy of little sympathy from foundrymen. "A Buyer" is now filling the rôle which foundrymen were made to fill before the war, as at that period the shortage had not developed sufficiently to affect the competitive element; foundrymen were practically in the hands of buyers of castings generally. They knew how to take advantage of such conditions, and not usually to the benefit of the foundry. They could play off one foundry against another, thereby assuring that the castings were cheap and of good quality.

The "knock off" then in vogue may require some explanation. The "knock-off" system was generally as follows:—A casting which was quite good enough for the purpose for which it was required would be delivered, but some small defect would perhaps develop after the customer received it. This was sufficient for the buyer to call upon the founder, either to "knock off" something from the price of the casting, or to replace it. One can easily guess as to the course the founder would take; he would undertake to let the casting go at a lower price in preference to replacing it, but generally that meant a loss to him, as, without doubt, the margin of profit was the minimum—anything lower involved a direct loss. Many foundries unconnected with an engineering works, closed, or were continually changing hands, before the war, and when one remembers that buyers generally had brought this about, one does not have much sympathy with them to-day.

The patterns, in pre-war days, had generally reached the condition of firewood before their owners thought it necessary to replace them, and it speaks well for the skill and patience of the moulder that he could turn out a presentable casting from them. To-day the foundryman demands high-class patterns before he will undertake to make castings. Buyers no doubt will have met this feature, and for them it will be another grievance.

With reference to "A Buyer's" statement that all foundries are "full up" and not able to take on new-comers, the natural query arises, Who are the new-comers? Are they newly-established firms? If not, why are they forced to seek fresh suppliers of castings? Why cannot they now obtain them from their previous suppliers? If their treatment of the foundries in the past had been just, they would not have placed themselves in their present predicament.

"Full up" now, and also for a good number of years to come, is what buyers may expect. Slack conditions will only be temporary, the natural trend of events in jobbing foundries who make castings for other people; and, as before stated, until more moulders are trained, no quieter periods can be expected. A close survey of post-war conditions, with its high cost of material and labour, should satisfy "A Buyer" that the "alarming" prices of which he speaks are quite justifiable, and equally an examination of pre-war conditions would reveal that they were then "starvation prices."—Yours, etc.,

MANAGER.

GENERAL COREMAKING.

*To the Editor of the* FOUNDRY TRADE JOURNAL.

SIR,—I was very surprised, in reading your report of the meeting of the Coventry Branch of the Institution of British Foundrymen in the issue of January 6 of the FOUNDRY TRADE JOURNAL, to find that so little appears to be known of the advantages of the use of sea-sand cores.

No small wonder that the foundries of this country are so far behind those in America, when such an important branch of a most important Institution are still discussing the pros and cons of treacle and linseed oil for cores.

Also I noticed with regret that scarcely a mention was made of sea-sand cores.

Either the members are very inexperienced or unnecessarily prejudiced in that they were unanimous in disparaging the use of "patent binders." There are, on the market to-day, several excellent binders, but the trouble appears to be that only a few appear to be able to use them to advantage.

It is surprising to find that at such a meeting a member states that he cannot obtain good cores longer than 6 in. from a "Sausage Machine," and more surprising still that no other member raised a voice in dissension.

At the foundry where I am employed, the "Sausage Machines" (a Wadsworth and a Spermolin) are the most efficient labour-saving devices in the core section, and no difficulties are experienced whatsoever in obtaining cores from ½ in. to 2¼ in. diameter on one machine and up to 6 in. diameter on another, 2 ft. to 2 ft. 6 in. long, also the cores will overhang the plates 3 in. without breaking.

With regard to the discussion on "scabbing," I may say that scabbing from cores is practically unknown in this foundry, where sea-sand cores are used, the cores being blacked only with plumbago, which for small work is sprayed on to the cores.

Foundrymen conversant with motor cylinder and other intricate cores will perhaps be interested when I state that the most intricate of these are made at this foundry without rods or vents, from sea-sand mixed with a "patent binder" in certain proportions, which will stand up in the green state without packing.—Yours, etc.,

"OLD BILL."

January 10, 1921.

**REPAIRING PROPELLER OF A DESTROYER.**—An interesting repair was recently made on the starboard propeller of the American destroyer "Thornton," in the 1,000-ft. dry dock at Balboa. The propeller had been damaged by touching one of the banks while in transit through the canal. The ends of the blades had been turned back through half of a circle. The blades were straightened and brought back to their original surface. Cracks were welded, the broken tips of two blades were repaired by burning-on (casting new metal into a mould at the end of the tips in such a manner that it fused with the old metal), and the propeller was balanced and replaced.

## Gazette.

MESSRS. JASPER MOUNSEY & COMPANY (Alfred Mounsey and Herbert Joseph Langton), 7, Laurence Pountney Hill, E.C., iron merchants and agents, have dissolved partnership. Debts by H. J. Langton, who continues.

THE partnership between E. J. Glaze & Company (Chas. Geo. Bushell and Edgar John Glaze), Exchange Buildings, Birmingham, iron, steel, coal and coke merchants, has been dissolved. Debts by E. J. Glaze, who continues.

MESSRS. A. G. WAKELIN & COMPANY (Alfred John Wakelin and Albert Edward Lloyd), 71, East Lane, and 12 and 23, Hickman's Folly, Bermondsey, brassfounders, solderers and engineers, has been dissolved. Debts by A. E. Lloyd.

THE partnership between Messrs. H. C. Jackson & Company (Herbert Charles Jackson and Paul Henry Cheston), 21, Finsbury Pavement, E.C., founders, engineers and merchants, has been dissolved. Debts by H. C. Jackson, who continues.

IT has been resolved, December 30, that it is advisable to wind up Hematite Ore Concentrates, Limited. C. E. Parker, 130, Abbey Lane, Woodseats, Sheffield, is appointed liquidator. Meeting of creditors, Albion Works, Sheffield, January 17, at 12.

THE IMPROVED OPEN-HEARTH FURNACE COMPANY, LIMITED, London, E.C.—It was resolved, December 11, confirmed December 29, that the company be wound up voluntarily. A. E. Cave, Moorgate Court, Moorgate Place, E.C., F.C.A., is appointed liquidator.

THE partnership heretofore subsisting between Messrs. Downton, Taylor & Company (Archibald Taylor and John Alexander Downton), Hamilton Brass Works, Hamilton, and 69 and 71, West India Dock Road, Poplar, London, brass and iron founders, has been dissolved. Debts by J. A. Downton, who continues.

A PETITION for the winding up of Baynes & Partners, Limited (late Az-Nu Engineering Company, Limited), Merton Abbey, S.W., H. W. D. Soper, 7, Great Winchester Street, E.C., F.C.A., being appointed receiver. Stanley Evans & Company, 20 and 22, Theobalds Road, W.C., solicitors.

## Legal.

**Alleged Theft of Iron.**

At Cardiff Quarter Sessions last week, before the Recorder (Mr. Ll. Williams, K.C.), Christopher Bowles (32), foreman, James W. Seymour (21), James Perks (21), Joseph A. Robson (21), Ivor Rudd (23), all four rivet-warmers; John McMahon (40), labourer, and William Llewellyn Forsdike (52), metal merchant, were charged with stealing and receiving a large quantity of pig-iron, the property of Messrs. Guest, Keen & Nettlefolds, Limited, of the Cardiff-Dowlais Works. After a lengthy hearing, the jury acquitted Mr. Forsdike, who was ably defended by Sir E. Marlay Samson, who said, on behalf of his client, that all the evidence went to show that he did not examine the parcels of metal sold to the firm by Bowles, and even did not know of them until some time later, when the cheques came before him to be signed. The amount of trade done by the firm of Messrs. William Muir & Company during the year was about £100,000, and the quantity of metal handled inwards and outwards was over 20,000 tons. The quantity of metal with which this case was concerned was about 35 tons, a very small amount when compared with the volume of business that the firm was carrying on.

At the conclusion of Sir Edward's speech on behalf of the defendant Forsdike, the Recorder intimated to Mr. St. John Francis Williams that at least in respect of two of the defendants, Bowles and Forsdike, therewas no ground for the charge of theft against them to go before the jury. The charge was accordingly altered to one of receiving.

A verdict of guilty was returned in the case of the other prisoners, who were sentenced as follows:—Christopher Bowles (32), foreman, six months' hard labour; John McMahon (40) labourer, four months with hard labour; James W. Seymour (21), James Perks (21), Joseph A. Robson (21), and Ivor Rudd (23), all rivet-warmers, charged with receiving, were sent to hard labour for three months.

MR. WILLIAM REES, late foundry foreman of Messrs. John Williams & Sons' Globe Foundry, East Moors, Cardiff, was recently presented with a wallet of Treasury notes as a mark of appreciation of his services.

MESSRS. HIGHTON & SON, LTD., founders and engineers, notify that they have removed their offices, foundry and works from Graham Street, City Road, to 43, Ridley Road, Dalston, E.8., to which address all communications should now be sent.

## Personal News.

THE late Mr. Thomas Black, of 13, Beverley Terrace, Cullercoats, iron and steel merchant, left personal estate valued at £9,925.

THE SECRETARY FOR MINES has promoted Mr. Thomas Harry Mottram, Inspector of Mines for Yorkshire and North Midlands, to be Chief Inspector of Mines. This will necessitate Mr. Mottram's removal from Doncaster to London.

THE late Mr. Arthur Stevens, organiser of the Workers' Union, and formerly one of the workmen's representatives on the Sliding Scale Committee of the South Wales and Monmouthshire Steel Industry, left personal estate valued at £251.

MESSRS. ALFRED HERBERT, LIMITED, machine tool makers and importers, Coventry, inform us that, in order to cope effectively with the ever-growing export trade of this firm, it has been found necessary to institute a special export department at the London office, 64, Victoria Street, S.W.1. This department is under the direction of Mr. A. B. Wearing, who possesses a very extensive knowledge of overseas trading conditions.

## Deaths.

THE death took place recently of Mr. David M. Cunningham, managing director, Atlas Steel Foundry and Engineering Company, Limited, Armadale.

THE death is announced from heart seizure of Sir Lazarus Fletcher, a distinguished scientist, for some time director of the Natural History Museum, who recently died at his residence, Grange-over-Sands, in his sixty-seventh year.

THE death has occurred at Bath of Mr. Walter Pitt, M.Inst.C.E., founder and chairman of the directors of the firm of crane makers and engineers, Messrs. Stothert & Pitt, Limited, of Bath. He had been responsible for many patents, and was the leading authority on harbour constructional plant.

MR. JAMES DUNNACHIE, chairman and managing director of the Glenboig Union Fireclay Company, Limited, died at Glenboig House, on the 8th inst. Mr. Dunnachie, who had reached the ripe age of 85 years, was associated with industrial enterprise in Glenboig district for the past 60 years. The company over which he presided is probably the largest of its kind in the United Kingdom.

MR. J. B. EDLINGTON, of Kexby, near Gainsborough, who died on the 9th inst., was head of the Phœnix Ironworks, Gainsborough. Mr. Edlington, who was 88 years of age, established the works in conjunction with his brother, the late Mr. Thomas Edlington, in 1865, and they continued in partnership until 1893. On the retirement of his brother, Mr. J. B. Edlington joined the present company, of which he was managing director.

WE regret to announce the death of Mr. G. F. Adams, Chief Inspector of Mines in India, which took place, after a few months' illness, on the 10th inst. at a London nursing home. Mr. Adams was the eldest son of the late Mr. G. F. Adams, of the firm of Messrs. Forster, Brown & Adams (now Forster, Brown & Rees), mining engineers, of Cardiff. Educated at Elstree and Harrow, Mr. Adams started his mining career in South Wales at the age of 17. After holding different appointments as colliery manager, he passed the examination for Inspector of Mines in 1894, and was appointed Assistant Inspector in South Wales. In 1902 he applied for the post of Assistant Inspector of Mines in India, and proceeded to his new appointment in the April of that year.

## Company News.

**Dundee Coal Company, Limited.**—Dividend of 6¼ per cent. (1s. 3d. per share), payable in London early part of February.

**Carrick & Foster, Limited,** Shipley, iron and brass founders.—Capital £10,000. Directors: Mr. H. A. Foster and Mr. E. H. Foster.

**Gloucester Railway Carriage & Wagon, Limited.** — Interim dividend for half-year ending November 30 last, at rate of 10 per cent. per annum, less tax.

**Campbell, Russell & Wilson, Limited,** 15, Gordon Street, Glasgow.—Capital £1,000 in £1 shares. Private company. To carry on business as engineers' pattern-makers, boilermakers, etc.

**The Brass & Malleable Metals Company, Limited.**—Capital £2,000 in £1 shares. Private company. Subscribers: David S. M'Lintock, traveller, 40, Dudley Drive, Hyndland, Glasgow; and J. J. Boyd Gilmour, solicitor, 19, Glasgow Street, Ardrossan.

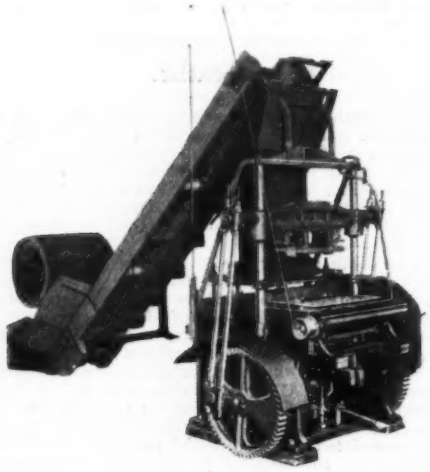
**Cubitts' Engineering Company, Limited.**—The directors have resolved to defer payment of the half-yearly dividend on the preference shares, which fell due on December 31, but anticipate being able to declare and pay the full year's dividend at the end of the financial year.

## Berkshire Automatic Moulding Machine.

Generally speaking, moulding machines are partly automatic—the machine performing but two or three operations, depending upon the attendant to complete the work.

The Berkshire moulding machine, shown in the accompanying illustration, is completely automatic. The screening of the sand is performed by the machine, and requires no attention on the part of the operator other than the initial pressing of the starting lever. The operator merely places the flask and bottom board in position, presses his foot on the starting lever, and in eight seconds, one-half of the mould is finished. The machine automatically puts the sand in the flask, rams it, vibrates the patterns, and finally removes it finished from the pattern. The detail of the operation is as follows:—

The flask and bottom board having been put into



position, and the lever pressed, the sand having been sifted in the riddle at the rear of the machine, and then conveyed in a bucket-elevator to the hopper above the machine. The flask is next automatically carried to the rear, where it is filled with sand. It then travels forward, and is met in its course by the bottom board, supported upon the ram, which is forced down, thereby ramming the sand.

At the instant of ramming, the vibrator is automatically thrown into action, which makes impossible the formation of any vacuum, and also prevents the sand from adhering to the pattern. The lifting pins then raise the flask off the pattern. While the flask returns to receive its supply of sand, the bottom board is supported by suitable hooks, but as the ram comes down, these hooks are drawn back so that the board remains upon the mould. All the operator has to do is to lift off the flask and set it to one side, blow the sand from the table with the air hose, and all is ready for placing the other half of the mould.

The pressure of the ram upon the sand can be quickly adjusted, and as the flasks are filled automatically, every flask will be rammed alike. It is also possible to adjust the boards in such a way that the drag will be rammed harder than the cope. When making the cope, the machine is so arranged that it cuts the sprue.

The vibrator is connected to the pattern support plate by an arm and is located in the machine away from the gas jets used for heating the pattern plates. The vibrator also is given an oscillating motion which is more effective than the longitudinal movement usually applied. The operation of the vibrator begins when the flask starts under the sand hopper and its period of operation is controlled by a cam on the main shaft. Increasing the time of the vibrator operation before compression results in jarring down the sand more effectively into all the pockets of the patterns. The vibrator continues to operate until the mould is lifted from the pattern plate. The height of the lift can be varied up to 3 in. The speed of raising the flask is controlled by a valve so that it can be lifted rapidly or slowly, according to the nature of the work. The air cylinder can also be used for drawing the patterns down through a stripping plate, if this is necessary.

The positive stop which centres the flask under the ramming head, effectively prevents the ramming of the sprue out of place. The clutch pulley on the shaft is merely intended as an emergency device to stop the machine.

The pattern plates are placed in an ordinary table, or platen, at the front of the machine, and can be changed easily and quickly by removing four screws which hold the plate in position, and slipping in the new plate. The machine uses split patterns plated on one side of a cast-iron plate, or stripping plate patterns.

Another feature is the heating of the pattern plates by gas jets from beneath, so that the moulds withdraw readily, without the use of any parting material whatever. With proper moulding sands, very fine work is made possible without employing facing-sands.

The wearing parts are protected, and so arranged that they may be easily adjusted; 3 h.p. is required to drive both the machine and elevator. The bearings are bushed and slides are gibbed.

This machine will mould from 60 to 80 complete moulds per hour. The European representatives for this machine are Messrs John Macdonald & Company, Pollokshaws, Glasgow.

## Metal-Heating Furnace.

An interesting type of a gas-fired furnace for hardening or tempering small metal articles in a non-oxidising atmosphere has recently been patented. The furnace comprises a heating-chamber *A* separated from the combustion chamber *B* and having beneath it a chute *D* through which articles tipped or dislodged from the hearth will fall into the quenching-bath *C* without being exposed to the air. The hearth *a* is preferably pivoted as shown,

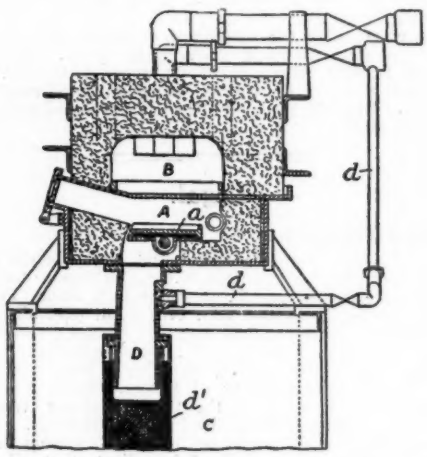



FIG. 1.—GAS-FIRED HARDENING AND TEMPERING FURNACE FOR SMALL ARTICLES.

or it may be mounted to slide, the articles being dislodged by a fixed rake; or where the hearth is fixed, a movable rake may be used to discharge the articles into the quenching-bath. Combustible gas is supplied to the chute *D* and heating-chamber *A* through the connection *d*, and openings may be formed in the roof of the heating-chamber through which part of the gas may enter the combustion chamber. A basket *d*¹ supported by the chute is provided to receive the discharged articles, and a screw pump may be fitted to maintain circulation of the liquid in the quenching-bath.

**CASTING HIGH-SPEED STEEL.** — The varied and complicated shapes in which many of the modern high-speed steel tools are used has raised the question of the possibility of the direct production of these forms by casting in specially prepared moulds. Considerable difficulty has been experienced in the commercial production of high tungsten steel castings, and this is largely to be attributed to the high-melting point of such steels. The practical difficulties have apparently been overcome by the United States High-Speed Steel and Tool Corporation. An electric arc furnace is employed for the melting of the high-speed steel, which is essentially of the tungsten-chromium type, containing in addition some vanadium. The moulds are made of a special "core mixture," and they are poured from hand ladles served from a large ladle suspended on a travelling crane. Cast blanks for milling cutters, large sized twist drills, and special rock drills are produced, and are claimed to have superior cutting powers.

# English and American Types of Electric Iron and Steel Furnaces Compared.*

(*Continued from page* 30).

By John B. C. Kershaw, F.I.C.

The 25-ton furnace, shown in Fig. 6, is the largest of the Héroult type yet designed, and it is very unlikely that larger furnaces than this will be erected; for, as Campbell has pointed out, there are mechanical and electrical difficulties met with in the operation of furnaces over 25 tons capacity which more than counterbalance the economy of heat which results from increase in size. The following description of the plant and operation of the triplex process of steel manufacture at the South Chicago Works of the Illinois Steel Company (where three of these 25-ton Héroult furnaces are installed) is drawn from a Paper

"The three tilting open-hearth furnaces, each of which has a hearth area of 892 sq. ft., are electrically-operated, and are so constructed as to be heated either with producer gas or with tar. Air chambers having 10,472 cub. ft. of chequer volume, and gas chambers having 6,734 cub. ft. of chequer volume, provide liberal regenerative capacity. Two 7½-ton charging machines and three 100-ton overhead cranes assure the rapid handling of material. The pit side of the open-hearth department is served by two 175-ton cranes, and is provided with a 330-ft. pouring platform capable of handling two sets of moulds.

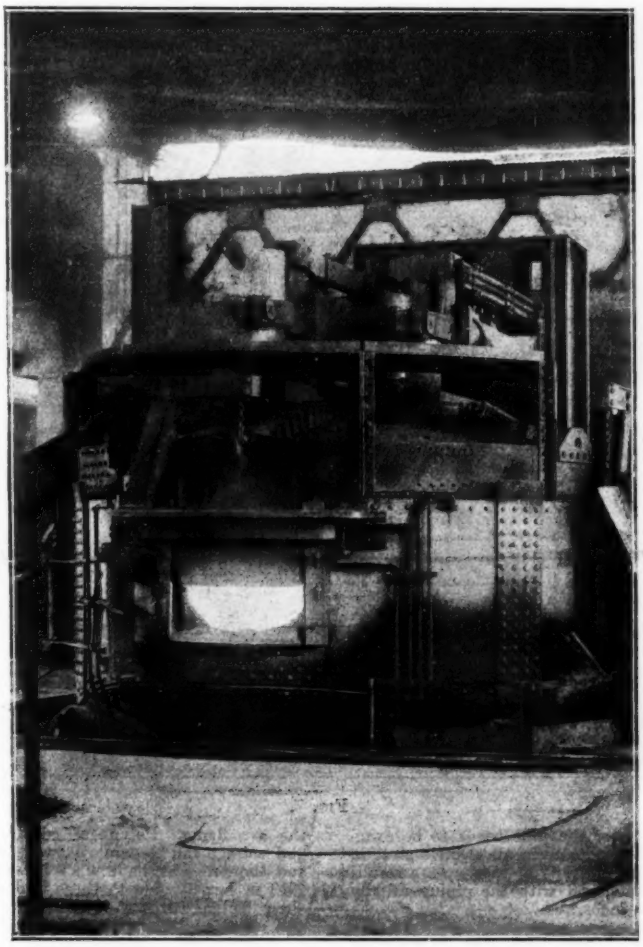


FIG. 6.

by Mr. T. W. Robinson, read before the annual meeting of the American Iron and Steel Institute in May, 1918. The South Chicago Works in 1918, it may be explained, were producing 140,000 tons of electric steel per year by the triplex process, and this tonnage it was expected would be considerably increased in 1919-20.

"There are two main buildings, one comprising the duplex plant proper, and the other containing the electric furnaces; as an adjunct to the latter there is a 1,500-ton forge press. In its essential features the duplex plant consists of two mixers, one of 1,300 tons and one of 306 tons capacity, two 25-ton acid-lined converters, and three 250-ton tilting open-hearth furnaces. The mixers are commanded by two cranes, one of 100 tons and one of 75 tons capacity. The mixer metal is transferred on an elevated platform to the converters by a 25-ton transfer ladle, operated by cable and winch mechanism.

"The Bessemer plant is designed for the ultimate addition of a third vessel. Its present capacity may be placed at 75,000 tons per month of blown metal, Bessemer ingots, or any desired combination of the two. The three tilting open-hearth furnaces, when operating on blown metal, are rated at 65,000 to 75,000 tons per month. The elasticity of their operation is self-evident, and it is obvious that their actual tonnage is dependent upon the character of the charge used. Two of these furnaces are running on open-hearth material, with Bessemer-blown metal as a base. The other furnace is operating on a nickel-steel scrap charge, with molten pig-iron additions, for further refining in the electric furnace by additional operations.

"The electric plant comprises three 25-ton Héroult furnaces, each with an adjacent transformer building. The capacity of the plant naturally is somewhat dependent upon the character of the steel made, but may be placed at 12,000 tons per month. This, with the output of the two old 15-ton furnaces, gives a total electric steel capacity of 16,000 to 17,000 tons per month, and

* "Electrothermal Methods of Iron and Steel Production," by John B. C. Kershaw. Constable & Co., London, 1913.

makes the South Chicago Works the world's largest electric-steel producing plant.

"In the case of the large electric furnace, it is more necessary than in the small furnace to consider the losses due to reactance in the electrical current. When one considers the relatively little power required by the original furnaces, it is evident that in the case of the larger furnaces, which are equipped with transformers of 3,750 kw. capacity, the question of power losses is an important one. In respect of the electric furnace load, from the central station standpoint, it is interesting to note that with four furnaces operating on the triplex process, 24-hour load-factors of 75 or 80 per cent. are not unusual. This compares favourably with other forms of industrial load. The furnaces ordinarily are operated with only a reducing slag, and care is taken at all times to see that such conditions obtain as will most thoroughly and quickly effect complete deoxidation. After the steel is thoroughly dead-melted, and the reactions are completed (as determined by the careful testing of the slag and metal), the current is reduced until a proper pouring temperature is obtained.

"The pouring of steel from the electric furnace is subject at all times to the careful control of pyrometric observation. For the production of a satisfactory steel, a proper casting temperature is an important element in all processes, but with the electric furnace special care is needed because of the high heats obtainable with the electric arc. Electric steel, on account of its freedom from gases, is specifically a dense steel, and in metal of this character the pipe tends to be exaggerated. It is the custom to teem all electric steel in inverted moulds with refractory hot tops. As a result, little difficulty is encountered with the piping usually found in the ordinary ingot.

"In connection with alloy steels, it is very necessary to guard against any condition that will tend to unequal ingot strains, and special precautions are taken to avoid undue surface tension in the moulds. Ingots are now cast weighing from 3,400 to 38,000 lbs., the uniform solidification of which is made the subject of the greatest care. Top-pouring, box-pouring, and bottom-pouring are resorted to, as the individual character of the steel best appears to warrant, and the entraining and inclusion of slag or other foreign matter is carefully guarded against."

### The Ludlum Furnace.

The Ludlum electric steel furnace is an American modification of the Héroult type, and is employed with three-phase current for melting down and refining iron and steel scrap. It has no bottom electrode, and the electric current is conveyed entirely by the upper electrodes which pass through the roof of the furnace. The Ludlum furnace differs from the Héroult furnace, however, in many details of its construction and method of operation, notably in the fact that the three electrodes are arranged in a straight row, and that they are permitted to dip into the metal bath and into the slag, and to produce a portion of their thermal effect by resistance heating. The hearth of the furnace is constructed elliptical in plan, and the central electrode is allowed to dip into the metal bath, while the two other electrodes are stopped just above the surface of the slag. The result is that the slag is heated by a combination of arc and resistance heating, and is maintained at a higher temperature than the metal beneath it, while the immersion of the central electrode in the metal bath causes a certain amount of movement and circulation at this point, due to the passage of the electric current from this electrode to the charged slag lying above it.

The constructional details of the Ludlum type of furnace are well brought out in Fig. 7, which shows a furnace of 3-tons capacity.

### The Rennerfelt Furnace.

The Rennerfelt furnace for steel-melting is the invention of a Swedish engineer, and is a modified form of the well-known Stassano furnace. It employs horizontal electrodes for forming the arc, and the thermal effect is produced by the heat radiated from the flame formed between the two or more horizontally-placed electrodes. The Rennerfelt furnace differs from the Stassano furnace, however, in possessing a vertical electrode, which, owing to its electrical polarity, forces the horizontal arc flame violently away from itself, and down on to the surface of the metal or slag lying beneath it. This leads to rapid heating of the charge, and also protects the roof from the destructive effects due to the high temperature of the arc flame. Polyphase current of any frequency and voltage can be employed with this type of furnace, and the progress made since it was first introduced in 1912 is largely due to these two advantages over the older Italian furnace of a similar type, first designed and operated by Stassano in the year 1900.

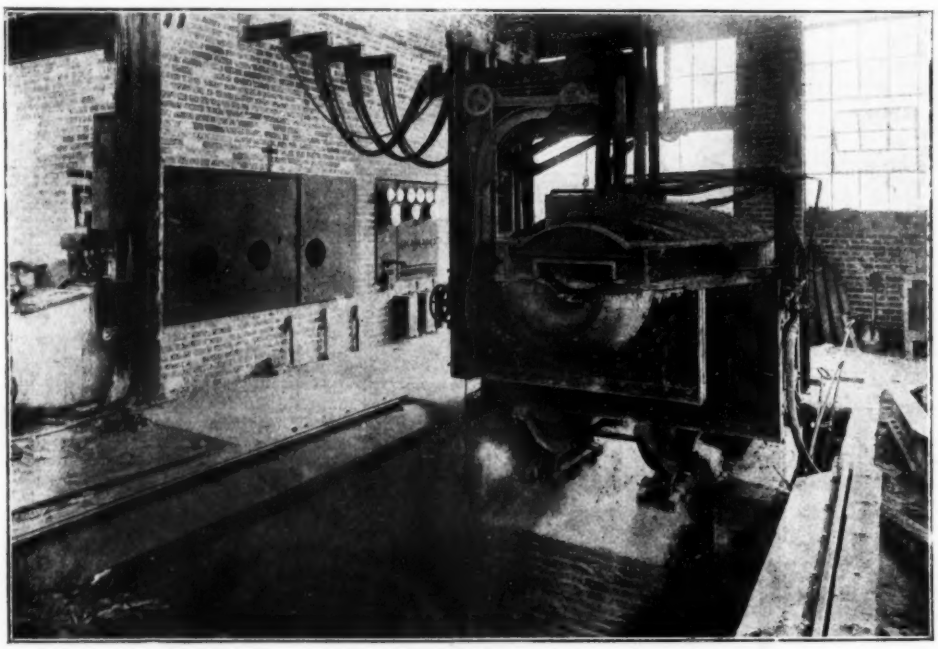


FIG. 7.

The following description of the construction and methods of working the Rennerfelt furnace is drawn from two Papers by Vom Baur, contributed to recent meetings of the American Electrochemical Society, and recorded in Vols. 29 and 31 of the "Transactions" of that Society. When three-phase current is employed for operating the furnace it is transformed, by means of a Scott connection, to a two-phase three-wire system. The middle or combined conductor carries about 40 per cent. more current in the vertical than in either of the side electrodes, and this forces the entire large radiating arc, by the resolution of forces and electro-magnetic action, down on the bath. The horizontal electrodes are 15 in. above the bath or slag in some of the larger-size furnaces, and the operating distance from tip to tip of the horizontal electrodes is usually from 18 to 22 in. or more. These dimensions give an idea of the size of the flame, which, striking the bath, mushrooms to the sides and ends of the furnace. The heat reaching the roof is consequently very indirect, thus favouring low roof-maintenance costs. The roof repairing costs, in fact, have been proved to be low in practice; for instance, when melting cold steel scrap and making tool steel with heats taking 5 to 6 hours in a low-power furnace, at about 150 kw.

per ton. the roof has lasted 192 heats with a 9-in. brick. With faster melting, and a 12-in. brick, more heats could be expected from one roof.

The furnace is built in different sizes. The first 30 furnaces were of 3 tons and under in capacity. Since then, 4-ton and 8-ton furnaces have been placed in operation and 12-ton and larger are being contemplated. Rennerfelt himself believes that with the multiple-arc system, electric furnaces of 40, 50, and even 75 tons capacity can be made, and run to give satisfaction.

On account of the peculiar characteristics of the Rennerfelt arc, it is very steady with hand regulation, and the furnace operation is electrically-simplified to a marked degree by avoiding all automatic electrode regulation, although motors with push-button control are contemplated. Only 4 or 6 lbs. of Acheson graphite are consumed per ton of cold steel scrap or pig, melted and treated. The furnaces can be constructed with either basic or acid linings and bottoms, and these last as long as the similar solid bottoms of open-hearth furnaces.

In his second paper Vom Baur described improvements in the original design and method of operating the Rennerfelt furnace which have not only rendered it more efficient as regards thermal effect, but have also reduced the working costs. The furnaces in use in America are now made circular in shape where one set of electrodes is employed, and oval in shape when two sets are used. The side electrodes can be moved upwards or downwards as desired in a vertical plane,

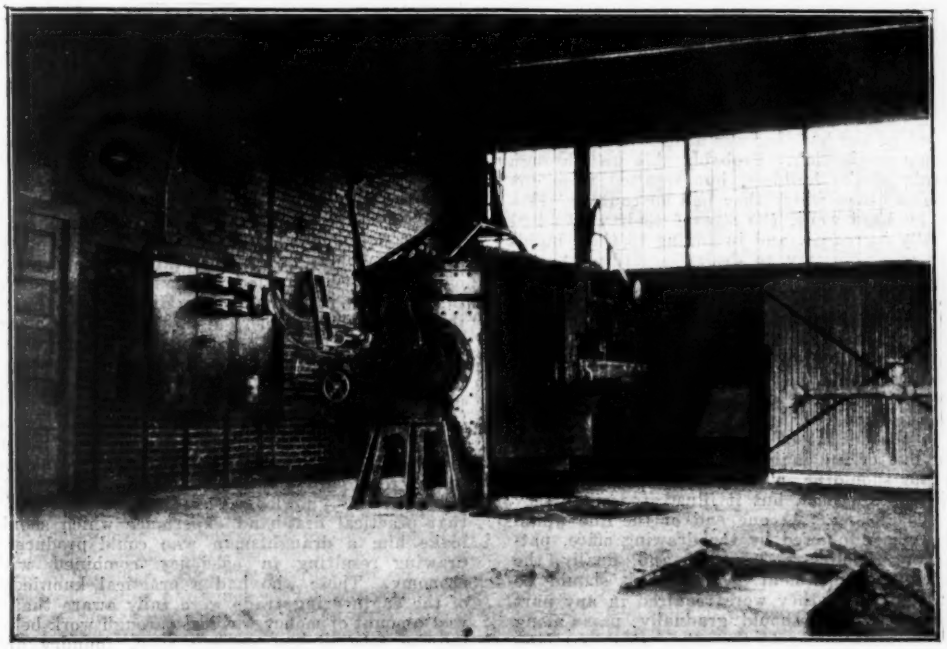


FIG. 8.

and the power for a given size of furnace has been largely increased. The electrode tips are now brought to within 3 in. of the surface of the metal, and this, together with the larger power which is available for the initial stages of the refining process, has naturally reduced the time required for melting the charge of cold scrap.

With furnaces having 300 kw. power per ton of output, heats have been made on basic bottoms (taking-off one slag) in 2½ hours, with 670 kw.-hours per ton, when operating continuously. With acid bottoms and 200 kw. power per ton of output (taking-off one slag) good steel and full heats have come off in 3¼ hours, with 635 kw.-hrs. per ton. The electrode consumption in these furnaces is less than 6 lbs. per ton of steel made, operating continuously.

Some additional figures for the consumption of power and electrodes with the Rennerfelt furnace are given in an article by Rennerfelt and Von Eckermann in the "Journal du Four Electrique." The furnace used was small (only of 1.25 ton capacity), and the mean time per charge taken to melt and refine 12 charges was 6 hrs. 39 min. The charges consisted of 19½ per cent. Swedish grey cast-iron, 71 per cent. forge scale, and 9½ per cent scrap. During melting, ferro-manganese, ferro-silicon, small amount of aluminium, and about 1.8 per cent. of the charge weight of Kiiruna iron ore were added. When the furnace was operated intermittently, the consumption of carbon electrodes averaged 5.1 kg. per ton of metal, and the electric energy 1,000 kw.-hrs. With continuous operation the latter figure was reduced to 800 kw.-hrs. per ton of steel, and 90 per cent. of the metal charged was obtained in the ingot, after casting and trimming. As regards the latest developments of the Rennerfelt furnace in the U.S.A., Messrs. H. A. de Frieg and J. Herlenius, in an article which recently appeared in "The Iron Age," state that in the newer furnaces the electrodes are so arranged that the arc can follow the charge as it melts down, and in some cases the electrodes are tilted to such an extent that the arc forms between the electrode and the slag. It has been found, however, that the highest efficiency is obtained with the Rennerfelt furnace when a constant distance is maintained between the tips of the electrodes, and also between these tips and the top of the charge, and a number of improvements have been made in the electrode mechanism designed to attain this result. The larger furnaces are now equipped with a cradle and rack, and the time required for desulphurising and killing in the basic process has been considerably shortened by decreasing the depth of the bath. Fig. 8 shows a Rennerfelt furnace installed at the Oklahoma Iron Works at Tulsa, Oklahoma, for the production of steel castings.

**ANNEALING WITH PULVERISED COAL.** — In a Paper read before the Columbus meeting of the American Foundrymen's Association C. H. Gale, Pressed Steel Car Company, McKees Rocks, Pa., stated that where the investigations were conducted, a marked difference in the physical characteristics of steel was noticed after pulverised coal was substituted for gas and oil for the annealing furnaces. The tensile strength became greater and the carbon and sulphur content was increased. The average carbon content before annealing was 0.262 per cent. and after annealing 0.287 per cent.; the sulphur content before annealing was 0.043 per cent., after annealing 0.052 per cent. These elements showed the greatest increase after the first annealing. Thinking that possibly the fuel had a case-hardening effect upon the steel, drillings were taken from test bars and these showed that the increase in sulphur and carbon is considerable near the surface, but decreases as the depth below the surface increases. Samples of malleable iron containing 0.044 per cent. sulphur before annealing showed no increase in sulphur when annealed with gas, but the sulphur content was increased to 0.501 per cent. when annealed with coal. Mr. Gale, in reply to questions, said that the type of combustion chamber might make some difference with the results. In the foundry, referred to in his Paper, the annealing furnaces had no combustion chambers. The coal was blown directly into the furnace and the metal could easily absorb the elements from the fuel. The foundry was engaged in making only ordinary commercial castings, not alloy castings, which ran from 29 to 31 tons per sq. in. in tensile strength. When pulverised coal was used the tensile strength was increased to 35 tons per sq. in., but when they changed back to oil the tensile strength dropped back to 29 to 31 tons.



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# The Relationships Between the Drawing Office, Pattern Shop and Foundry.*

A meeting was held at the Municipal Technical School, Suffolk Street, on Saturday, November 13, when a paper on the "Relationships between the Drawing Office, the Pattern Shop and the Foundry" was read by Mr. W. J. Flavell. Mr. F. Holberry (Branch-President) was in the chair. The nominations of four new members were approved.

MR. W. J. FLAVELL said that a paper on this subject might seem to some to be rather superfluous, but he thought they might all consider with advantage whether the relationship as it existed in some of the works could not be improved. They wanted the whole of the various departments to be so working in conjunction one with the other to form one complete organisation capable of turning out the work, in whatever form, to the best advantage from every point of view. A great deal might be said with a view to bringing about better results in the engineering industry of the country. They were living in a time when they must face these questions, for undoubtedly, with the growth and enterprise of other nations, this country, unless we adopted the best and most up-to-date methods of organisation and machinery, would be left behind in the trade of the world.

Undoubtedly some of those present had been in works where it was obvious to anyone, however small his knowledge of the engineering trade, that the plan of the building was altogether wrong for economic production. Probably this was through no fault of the builders, but resulted from circumstances over which they had no control. Possibly, by hard work, the size of their works had gradually increased, and in adding to their building it was necessary to design according to the land they had at disposal. That often meant working under uneconomic conditions. Inadequate space, the necessity of handling work twice when once would serve, and other difficulties conduced to increased cost, and although some of the items which might be eliminated were very small taken singly, if multiplied and considered as going on all through the year made an appreciable difference in the output of any firm. His idea of the laying out of an engineering works was that all the shops should be in a straight line; of course, this is not practical, but it illustrated what they were considering. At one end of the line would be the office, followed by the drawing office, pattern shop, foundry, fitting shop and, finally, the despatching department. The goods should be brought to where they were required in any part of the works, and should gradually pass along from one department to the other until, arriving at the final department finished, they should be despatched to their destination.

The drawing office was the starting point where, after the order had been placed on the books, the work of production began. He had often thought that the drawing office was placed in the wrong position. Its work was very closely connected with that of the pattern shop, foundry and fitting shop. Yet how often had they seen in large establishments that if a foreman wished to ask any question of the chief draughtsman he had to walk quite a distance. It might be said that nearly all works had their telephones, but although many questions could be asked and answered by this means, the telephone was not conducive to that close exchange of thought and opinion which should exist amongst the heads of the various departments. The position of a head draughtsman should be that of a leader in the works, the one whose skill and knowledge had thought out the design of the machine, which he conveyed to the various heads of departments by means of drawings, etc. But he should not be above receiving opinions and ideas from the various foremen in the works. This he said emphatically, because he had known cases where foremen had suggested alterations which would be for either better design or better output, but where their ideas had been resented rather than gladly received. This, of course, was wrong, and he did not wish to assume that it was common.

With regard to the design of the drawing office, everyone would say at once that such an office must be well lighted and ventilated and be well provided with books of reference. The chief should have a small office with a glass partition, and this should, for convenience, be at the end nearest the pattern shop or foundry. Systems of numbering, filing, and tabulating drawings for easy and expeditious handling and reference existed, of course, in any well-ordered office, so that the chief might at any time be able to refer quickly to any drawing, and so be able to answer any query or question asked by a foreman from one of the various departments.

Let them for a moment consider the draughtsman and his work. The remarks the speaker had to make applied more closely to the engineering and foundry trades rather than to the constructional trades, such as bridge and girder building. They knew perfectly well that a man to be a successful draughtsman must devote a large amount of study and thought to his work, and then his training must be of the very best. The present-day practice in training a draughtsman was altogether wrong. This was rather a strong statement, but he made it advisedly, because he was convinced of its truth. In time past the young man who desired to become a draughtsman was engaged for the first period of his time in the various departments to give him a practical experience of the work. If he was a youth with his eyes open he could thus acquire knowledge that was absolutely essential to him when the time arrived for him to make a start in the drawing office. But to-day a lad was taken into the drawing office direct from school. He began by entering up drawing numbers and putting them away; he was then allowed to do a little tracing; and gradually, if he showed any capacity for drawing, he was allowed to make a drawing of some simple piece of work, and in a few years became capable of making a well finished drawing—as far as appearance was concerned. He might be a young man who was anxious to make himself proficient in his work and had studied at night classes to gain further knowledge, but he had never had that practical first-hand experience which should make him a draughtsman who could produce a drawing resulting in efficiency combined with economy. Those who had a practical knowledge of the engineering trade were fully aware that a vast amount of money was lost through work being put on jobs in the pattern shop, foundry and fitting shop which might have been avoided if the design had been in the hands of a draughtsman who had been through the shops. The speaker could give many instances illustrating this, but he would content himself by saying that the present kind of training for draughtsmen was not fair to the man, and did not give to his employer those results which were necessary to form that closer relationship with the various departments which should be obtained.

The pattern shop was a department which stood very high in the works for efficiency, and could be made to form a close link in relationship to the other departments; but sometimes sufficient consideration was not given to its welfare and equipment. It was a trade that within the last few years had developed in its demands upon the skill of the men engaged in it; more highly complicated and highly finished patterns, especially in the motor trade, had to be made, and the ability of the patternmaker was tested to the utmost. Some pattern shops had not had that care and thought bestowed upon them in construction and equipment which they deserved. This was wrong, for it was necessary that the pattern department should be worked on the best lines if they were to have that close relationship which they all wished for. As an example of the work of the pattern shop, Mr. Flavell, with the aid of the blackboard, described the marking out for the

* Paper read before the Birmingham Branch of the Institution of British Foundrymen.

pattern of a helical-toothed wheel, remarking that such wheels appeared harder to make when looked at than they really were. He then described the best method of making a helical pinion pattern.

Mr. Flavell went on to say that the relationship between the foreman patternmaker and the foreman moulder must be very close and intimate if the best results were to be obtained from both departments. One was dependent on the other, and neither could succeed as it should, without close interchange of ideas by which one could ultimately arrive at the best way of doing a job, whether large or small. He was inclined to think that some firms looked upon a pattern shop as a necessary evil, since its work did not leave the establishment after it was done. Surely this was altogether wrong. The department was one without which the work could not be done. It was an expensive department, and therefore the best methods should be used for obtaining the best results. This was being carried out in modern foundry plant, where they had not the miserable dark shop which existed years ago, and these improvements should be extended to the pattern shop. First of all, light was essential for good work, especially upon small light castings, which had to be made with great accuracy. Ventilation in the summer and warmth in the winter should be carefully considered, for the writer had known many shops so cold that a man had not been able to hold his tools properly to do his work. These were simple things in themselves, but they were important with regard to quality and quantity of work. The shop should have a place where a man could wash, and the shop should be kept clean, for if they wanted good, clean work they must have in all departments, as far as possible, clean surroundings.

Turning to the foundry, this highly important department was receiving to-day more attention from the heads of works than in the past, in many and various ways, all making for that close relationship to the other departments which should exist. More attention was being given to the scientific side of the work, and there was more observance of sanitary requirements. There was nothing to be gained nowadays by discussing whether the chemist or the practical foreman moulder was the most important man in the foundry. They were both absolutely necessary in a foundry of any magnitude, and where both were working together, each in his particular sphere, each advising and helping the other, the highest and best results were bound to follow. There were hundreds of foundries whose size and output were not sufficient in volume to justify the engagement of a metallurgical chemist, and in these the work of mixing metals, etc., had to be done by the foreman moulder. He knew a number of such men who had studied hard, not only the practical but also the theoretical side of their business. These were extremely useful men, who had attained to their position by hard work and close study.

With regard to the work of a moulder, there was a great deal of misunderstanding in the engineering trade as to what was required in a good moulder. It was a trade requiring the highest skill, but, unfortunately, it was divided up into many parts. There was the kind of moulding that was simply repetition work year in and year out; there was the machine-moulding which was used in many instances for standard jobs, and there was the class of moulding for rough, easily moulded work or for open-sand work. None of these required much skill or knowledge on the part of the moulder, and there were some whose idea of moulding was that it was not a very skilled trade. But, beyond all this, there was still the large volume of work which could only be made by a man who thoroughly understood his trade and was capable of turning out a good casting, however complicated the job might be. There was a wide field for a man to make himself efficient, from the large casting weighing perhaps 40 tons, down to the small and very light intricate casting weighing only a few pounds. However much might be done by machine-moulding, there was always work for the good moulder.

He would like to say how very useful and helpful to the trade the Research Institutions were which were being started throughout the country. They had one just coming into being in the Midlands, and he felt confident that it would be of great service to the foundry trade in that district.

With regard to the foundry itself, what applied to the pattern shop applied very closely there. One of the greatest assets to a foundry was plenty of light. Those whose experience dated back for any length of time would know the miserable dark shops from which a moulder was expected to turn out good, clean castings. Their forefathers seemed to have designed foundries as they designed houses, as if they were afraid of plenty of light coming into the buildings in which they had to live or to work. He was glad to say that this defect had been largely removed in modern shops. Their foundries were designed so as to afford better conditions for men to work in, and this tended to uplift both the quality of the work and the moulder's position.

It might seem strange, but it was true, that in some districts, at least, there was great reluctance on the part of parents to let their lads learn the trade of a moulder, though there was nothing like the same reluctance with regard to patternmaking or fitting. He supposed that a great deal of this reluctance was due to ignorance of the trade and to the fact that it was a trade in which a lad had to get his hands and face black. The latter objection could easily be got over, and without much expense, by providing a place in connection with the foundry where a man could wash himself and change his overalls. Further, he did not think sufficient thought and attention was bestowed upon this branch of the engineering trade by local authorities. Every good technical school should have its small foundry, and the good points of foundry work as a skilled trade should be brought out occasionally by schoolmasters and others in the engineering districts of the country. By such means they might be able to get a better supply of the sort of lads they wanted in their foundries.

He had referred to the close feeling of friendship which he considered should exist among the heads of all departments. In conclusion, let him say how necessary it was that all these heads of departments should be men of wide knowledge, firm but kind, students of human nature to a certain extent, tactful, knowing when and whom to advise, to caution or to praise. He had tried, roughly, in a simple way, to show how they all, by each doing his bit, whatever his position, might bring about those closer relationships of one department to another which they all knew were necessary to success.

### Discussion.

THE BRANCH-PRESIDENT said that he was entirely in agreement with Mr. Reason as to the desirability of having a greater number of practical papers. Probably 75 per cent. of their members were practical men, and they should try as far as possible to cater for them. He quite agreed with Mr. Flavell's ideas as to the construction of buildings, but what Mr. Flavell had given them was an ideal, and, as Mr. Reason had remarked, could not always be fully realised. He thought, however, that employers would do well to pay more attention than they did to the arrangement of their works and that many firms could lay out their works to greater advantage than was commonly the case. With regard to the training of draughtsmen, he quite agreed that if young men before going into the drawing office had a little experience in the pattern shop, the foundry and the machine shop, they would realise some of the difficulties of working to their drawings. There would then be more sympathy with the difficulties which each man in his particular sphere encountered, and they would have more consultations between the different departments. At the same time he thought that a foreman, and especially a foundry foreman, should have a knowledge of drawing, so that he might be able to point out to the draughtsman the defects in a drawing from the foundry or the patternshop point of view, and be able to tell the patternmaker how to make his pattern from the drawing. As to the making of a helical-toothed wheel, he was keenly interested in Mr. Flavell's description, but he agreed with Mr. Reason that it was not quite so easy as it looked.

XUM

MR. C. HEGGIE said that he agreed with Mr. Flavell as to the principle upon which works should be planned, but he thought they all agreed that sometimes it was quite impossible to realise the ideal. With regard to the relationship between the draughtsman and the foreman patternmaker and the foundryman, much depended on the size of the works, the management and other circumstances. He quite agreed that the draughtsman should begin his training in the foundry and the patternshop. Further, as far as possible, boys in the foundry ought to spend time in the drawing office. To be a good draughtsman one must understand the making of patterns and the processes of moulding, whilst a patternmaker who had been in the foundry a year or two, or even for six months, would be all the better for it as a patternmaker. He had known men in patternshops in Birmingham who had never been in the foundry, and from whom one never got a good pattern. The foundry manager of to-day was a very different man from the foundry manager of a few years ago. And for that the thanks were due in a great measure to the Institution of British Foundrymen. The ordinary moulder was also a very different man from what he used to be. The foundry manager ought to understand drawings, and, if qualified, should be constantly brought into consultation with the draughtsman. It would often be possible for the draughtsman, after consultation with the foundryman and the patternmaker, to make the work easier for both. Some things in a design were essential, whilst others were not and could be easily altered to facilitate the work of the foundryman. In a pattern shop a great deal of expense might be incurred in making a pattern in such a way that it would not be easy for the moulder, and that expense might be saved if the moulder was first consulted. A wise manager would bring all these men together, and if they could not agree, he could be the judge. These difficulties happened even with light castings. There were many things in which the design had to be balanced, but often by keeping one part a shade thicker than the other a better casting could be got. The draughtsman and patternmaker should know how the castings were to be run and where the runners ought to be, because the putting of a runner on at a certain point often made all the difference between success and failure in casting. If such things were discussed together by the draughtsman and the patternmaker and the foreman moulder, little alterations could be made which would greatly facilitate the work without interfering with the design. As they all knew, castings, if designed without regard to foundry conditions, were liable to internal strain, which, if they did not break out in the mould, would probably show themselves in the stores weeks or months afterwards.

MR. CRESSWELL also agreed with Mr. Flavell that draughtsmen, especially in the engineering trade, should be men who had first-hand knowledge both of patternmaking and of moulding. A draughtsman who had been in both those shops would make much better designs, because he would know how the pattern could be made most easily and how it should be moulded after the pattern had been made. The draughtsman could assist the patternmaker very considerably by altering the design in consultation with the foreman patternmaker. A thing might be absolutely right from a theoretical point of view, but from a practical point it might not be so easy. Draughtsmen who had been trained in the foundry and patternshop were always ready to make these slight modifications, though, of course, sometimes there were things which were strictly specified and could not be altered. Sometimes the foundryman could not be made to understand why certain things could not be altered. That showed the desirability of the foreman in a moulding shop having had as a youth a good training in drawing, and also some experience in the pattern shop. As to youths going into the foundry, he thought that employers did not give sufficient consideration to that matter. Greater inducements should be offered. It was a dirty trade, and though in many works washing accommodation was provided, they wanted to go farther than that, and insist on its being used. They ought to start a little earlier; boys should be taught cleanliness, if they were to be clean at their work. At all events, he thought that the matter of dirtiness would be got over in course of time. The youths should also be encouraged to attend technical classes, and the large employers might give the youths one or two afternoons every week for this purpose.

MR. W. BAKER (Wolverhampton) said that from his experience there seemed to be a natural aversion amongst boys to going into the foundry because it was so dirty. Whatever facilities might be provided in the way of washbowls and so on, the work itself was of a dirty character. He did not think that the system of training draughtsmen advocated by Mr. Flavell would be adopted to any large extent by employers. Apprentices would be engaged for the drawing office and the pattern shop, and an interchange of departments would not be encouraged. The only solution of the difficulty was the technical school. Some eighteen months ago he was called in by the Wolverhampton Technical Instruction Committee with regard to the establishment of a class to suit foundrymen. It was decided that a class should be formed, and he was given a free hand in the equipment of one of the laboratories for moulding demonstrations. This year the scheme had been developed on the lines that students who attended the foundry class must take courses in foundry patternmaking and engineering drawing. The only practical work in the course was practical demonstrations in foundry work. He drew up a syllabus that he considered fairly comprehensive, and he made a point not of teaching moulding but of demonstrating to the patternmaking student the faults which foundrymen often found in patterns. This system applied with particular advantage to those employed by firms which had not their own drawing offices and pattern shops. There were many patternmaking firms not connected with foundries; the drawings were sent to them, and the patterns that were produced under such conditions were in many cases simply pieces of clever work made without any idea of facilitating the production of the casting. He had endeavoured to point out such faults and to demonstrate them for the patternmaker's benefit in the sand. He thought that if such schemes were more widely adopted in industrial centres they would prove the solution of the difficulty.

MR. PARSONS thought they would agree that the relationship between the pattern shop and the foundry at the present time left very much to be desired. If co-operation could be carried out on the lines suggested they would not so often hear the expressions which the moulder sometimes used when he drew his pattern.

A MEMBER suggested that there should be technical classes not only for youths but also for men who had not had the advantage of such instruction when young. He would like to know whether Mr. Flavell could suggest a quick method for dealing with change wheels for mowing machines.

MR. W. PEERS said that a foreman moulder should not be asked to give his opinion upon the spur of the moment, but should be allowed time to study the drawings.

MR. J. S. ROGERS said that at his works some time ago an arrangement was adopted by which a number of articled apprentices were taken. It was suggested that the apprentices should go in the old way first into the pattern shop, but the chief engineer preferred that they should go first into the foundry. They had already twenty boys who had spent six months in the foundry, and had then gone through the pattern shop, and they were far more in touch with patternmaking than those who had gone direct into the pattern shop. The boys who had gone through the foundry had far less trouble in understanding patterns. The men who had gone through the foundry, the pattern shop and the fitting shop into the drawing office showed much more intelligence than those who had gone into the drawing office direct, and they could be put on to complicated work within a few months.

MR. REASON thought that the statement made with regard to technical training was very important. He did not think that it was so necessary to-day as it used to be to give youths time off in order that they might attend classes. Now that the hours were 47 a week no man ought to

have any difficulty in attending classes. The classes at the Birmingham Technical School were of inestimable value for any man who wanted to improve his position. The opportunities of study for youths were going to be greatly extended. All boys who reached the age of 14 in June this year would after January 1, 1921, have to be allowed by their employers two hours a week for school work, and the educational authorities were making the necessary arrangements for the training of these boys. During the first twelve months there would be no set course for the student, because it was not always certain that the boy would remain in the same industry; but after that the boy would probably have decided upon his future occupation, and classes would be provided which would be suitable for each case. That, however, whilst it would be valuable for the future, did not affect those who were already in the trade, and he would advise them to take advantage of the facilities which were provided in Birmingham and other large centres.

MR. BAKER said that at the present time he had a class of twenty. No student was eligible until the age of 16, and, in addition to the youths, they already had four foremen in the class. A foreman might be a very skilful man, but there might be some departments in which he had not had experience. For instance, he might be thoroughly competent with regard to sand moulding and the use of plain patterns, but might not have had any experience with loam moulding, and would not know how to set the strickles. In such cases men were glad to have the opportunity of attending a class.

A MEMBER remarked that he had attended classes, and had not been ashamed to work alongside boys, and there were men twice his age in the class. Another remarked that they had to work with boys in the shop, and he could not see any objection to working with them at the technical school. There was one thing, he added, which he had studied by himself unsuccessfully for a month and which he learnt in one night at a class.

MR. H. L. REASON, who proposed a vote of thanks to Mr. Flavell, said the idea of having all the departments of a works in one line strongly appealed to him. They had, however, to remember that it was not always possible to obtain a long strip of ground on which to build a works. More generally the site available was square rather than oblong. Still, he quite agreed that the drawing office should be near the pattern shop. The little discussion with regard to helical change-wheels had been particularly interesting. He had had a little experience in making the ordinary class of gear wheel, but he had always looked upon the helical wheel as one calling for the highest skill of the patternmaker. Mr. Flavell had tried to show them that it was quite easy, and no doubt those with experience in the works could follow his description, but perhaps to some of them it was not quite so easy as it looked. With regard to the Research Association which had recently been formed for the foundry industry, that was a matter which was very dear to his heart, and, with a few others, he had been doing the pioneer work. When the Association had been organised and manufacturers began to take an interest in it, they would find how little they knew and how necessary it was to improve their knowledge. When things did begin to move in that direction they would see more of what Mr. Flavell desired, namely, closer co-operation amongst the various departments. As those concerned became aware of the difficulties arising from the absence of such co-operation they would see the inadvisability of works being run on the lines of watertight compartments. There were at present too many dirty black lines ruled between the different departments, and, taught by the lessons of the war, they were all hoping to get better results by closer co-ordination. As to recruiting the foundry staffs, it was very difficult to get lads into iron foundries, and still more difficult to get them into brass foundries. This, he thought, was due to lack of knowledge on the part of the parents as to what was required in the industry. The foundry trade was paying the penalty of allowing itself to become a neglected industry, and it would take a long time to put this right. He believed that in most works now the question was being tackled very seriously, and he hoped that in the near future they would see the industry become one into which boys would be proud to enter.

MR. J. BAGNALL JOHNSON, in seconding the vote of thanks, said that as an old patternmaker he highly appreciated much of what Mr. Flavell had said with regard to close co-operation amongst the various departments in the engineering trade. It was necessary for draughtsmen to serve part of their time in the pattern shop and in the foundry, but he thought it was even more necessary for the patternmaker to serve a short time in the foundry. The best patterns he handled were those made by men who were in close touch with the foundry. But too many of the patterns they had to-day were made by men who seldom saw the inside of a foundry, and who therefore could not know what was actually wanted.

The vote of thanks was heartily accorded.

MR. FLAVELL, replying on the discussion, said that he had accomplished to a certain extent what he had intended. His idea was to give a paper upon which any member could express an opinion. He looked upon that Institution as one great brotherhood filled with one desire, namely, to help each other. Upon a simple subject like that the discussion was more important than the paper. With regard to the design of the works and the position of the foundry, he gave what he considered to be theoretically perfect, but he did not say that it was practicable. His point was that too often the design was altogether wrong in regard to efficiency and economy. As to his illustration of the helical-toothed wheel pattern, if anyone wished any assistance in the matter he would give it with the greatest of pleasure. They were associated together with the one object of furthering their industry, and, through that, benefiting their country. With regard to change wheels for wheel-moulding machines, he did not know of any method better than the ordinary one. He thought that they had had that evening some downright good advice with regard to classes. They should get all the knowledge they could, and whatever knowledge they got, whether in the technical school or in the foundry, it was sure to be useful. Anyone who joined that Institution did so with the intention, he did not doubt, of gaining knowledge. He hoped that at their meetings they would not leave all the speaking to the older members. They had a very good programme of practical papers for the present session, and nearly all the papers would be given by local men.

## Small High-Temperature Electric Furnace.

MR. W. FAITOUTE MUNN, in a recent issue of "Chemical and Metallurgical Engineering," describes a convenient laboratory electric furnace for temperatures up to 2,300 deg. C. of the granular coke-resistance type using 1-in. graphite electrodes and a 1¼-in. graphite crucible. The rods, supported by suitable sized pipe-fittings, pass through silocel brick and continue to within about 1½ in. of the crucible. Granulated coke is used to fill the space around the electrodes and crucible. The crucible is made by sawing off a length of graphite rod of desired diameter and drilling out the centre in a lathe. The entire furnace is constructed of 9 × 4½ × 2½ in. silocel blocks, and is heated by an air-cooled step-down 2.5 kva. auto transformer. The primary is wound for 220 volts, having eight different taps for connections which give a voltage range of from 20.7 to 38 volts on the secondary. This arrangement does not require the use of any outside resistance, as the current and temperature are controlled by means of the various contacts on the primary winding and also by varying the pressure of the electrodes on the granulated coke between the electrodes and the crucible. The transformer is connected to the furnace electrodes with stranded copper cable. The corresponding amperes for the eight steps on the primary winding range from 65 to 120 amps., or from 78 to 144 amps., with 20 per cent. overload, which may be drawn for short intervals (20 to 30 min.) without hurting the transformer.

Temperatures as high as 2,200 to 2,300 C. have been obtained from the above, from a cold start, in 20 min. The cost of running is not over 30c (1s. 3d.) an hour figuring 10c. (5d.) a kw.-hour

# Aluminium and Its Alloys*—III.

By W. Rosenhain, D.Sc., F.R.S.

The various uses to which aluminium alloys have been and can be put, group themselves naturally into two divisions according as castings or wrought material have to be employed in each case. Castings, again, may be sub-divided into two groups—namely, the first group which are used in situations where they are not exposed to high temperatures, and the second group those in which exposure to high temperatures is essential.

In regard to castings of the first group, crank cases for aero engines, automobile engines, and many other purposes, may be taken as an example.

The specification ultimately suggested for this class of casting was an alloy containing from 12 to 15 per cent. of zinc and about 2½ per cent. of copper. This is far from being the strongest of the alloys of the zinc-copper aluminium series, but it combines the various properties required in what was believed to be the best possible degree. For the purpose of comparing it with other well-known casting alloys, Table I. has been drawn up, in which the tensile properties of this alloy, which is generally known as "L 5," are compared with those of the alloys containing 12 per cent. and 4 per cent. of copper respectively.

TABLE I.—*All Tests on 1-in. Diam. Rod.*

| Alloy. | Yield stress, tons per sq. in. | Ultimate stress, tons per sq. in. | Elongation, per cent. on 2 in. |
|---|---|---|---|
| Alloy— | | | |
| "L 5" sand .. | 6.0 | 9.3 | 2 |
| Chill.. .. .. | 8.2 | 13.4 | 5 |
| 12 per cent. copper— | | | |
| Sand .. .. | 5.0 | 7.9 | 1 |
| Chill.. .. .. | 6.4 | 9.7 | 1.5 |
| 4 per cent. copper— | | | |
| Sand .. .. | 4.9 | 7.5 | 5 |
| Chill.. .. .. | 5.4 | 9.6 | 11 |

When the "L 5" alloy came to be manufactured on a large scale, some peculiarities were met with. It was found that results which had been obtained at the National Physical Laboratory some years ago could not be readily reproduced in the works, and an attempt to reproduce them in the laboratory also failed at first. It was then discovered that these alloys undergo a gradual ageing process, which leads to an improvement in their tensile strength. Tests made on samples some months old therefore give higher results than those made on freshly-cast test-pieces, and this difference accounted at once for the discrepancies which had been found. The effect of this ageing is an increase generally of the order of two or three tons per square inch in the tensile strength. The ductility of these alloys is so low that any change in that respect can scarcely be traced.

In considering the values of various casting alloys, these ageing effects must be taken into account. In addition, however, some of the alloys are capable of being very considerably improved by heat treatment. Thus the alloy containing 4 per cent. of copper, remainder aluminium, is capable of being very much improved in mechanical properties by a prolonged annealing process. The object of this annealing process is to bring into solid solution as much as possible of the aluminium-copper compound, which, in the ordinary cast condition, is present in the alloys as a separate constituent. In the case of an ordinary chill cast test piece, this appears to require heating at a temperature from 450 deg. C. to 520 deg. C. for three days. As the result of this treatment, however, the tensile strength of the alloy is increased from 10 tons per square inch to 14.5 tons per square inch, while the elongation per cent. on two inches is increased from 10 per cent. to 20 per cent. This is, of course, a very remarkable improvement, but, unfortunately, heat treatment of so prolonged a period as three days appears to be expensive and may be difficult to apply in practice.

The second group of castings for which light alloys are required—are those which are exposed to high temperatures. Among these, pistons for aero engines, and also for other engines such as those used in tanks and submarines, constitute a most important group. At first sight it would seem that the obvious reason for using aluminium alloy pistons in internal combustion engines lies in the lightness of the metal and the consequent saving in weight of the engine. In the case of very large and heavy engines, such as those of submarines, this no doubt is the main reason for their use, and from this point of view they have proved particularly successful. On the other hand, in aero engines and in others where it is important to develop a maximum of power with a minimum of weight and petrol consumption, the use of the aluminium alloy pistons is justified from quite a different point of view. In these engines, in fact, the pistons when made of aluminium alloys are frequently made so much thicker in section that no saving in weight as compared with steel pistons is obtained. What is obtained, however, is a very important thermal effect. The thermal conductivity of pure aluminium is of the order of 0.52, as compared with 0.11 of cast iron. The aluminium alloys which are suitable for use as pistons do not quite attain the high thermal conductivity of the pure metal, but many of them attain a value greater than 0.40. Thus the heat-conducting power of an aluminium alloy piston is of the order of four times that of an iron piston of the same dimensions, and if the thickness of the piston can be increased in consequence of the lighter weight of the metal, the heat-conducting power is further augmented. The advantage from the point of view of the high-duty engine lies in the fact that with a piston having this high thermal conductivity, a greater ratio of compression can be used without leading to pre-ignition. The application of this increased compression, together with other subsidiary advantages which are obtained from the use of the aluminium pistons, has led to an economy which, in some engines, has meant an increase of power of the order of 20 per cent. as compared with the same engine working with an iron or steel piston.

In considering the question of the alloy to be used in the construction of an aluminium alloy piston, the temperature to which such pistons are exposed in service becomes a matter of vital importance. Unfortunately it is not easy to obtain exact and reliable data on this point. Some measurements which have been made by Dr. Gibson at the Royal Aircraft Establishment suggested that the maximum temperature does not exceed 250 deg. C.

Some purely metallurgical evidence which has been obtained in my own laboratory tends to confirm this view, as specially prepared specimens of metal inserted in some of these pistons did not show a change of internal structure which would undoubtedly have occurred on exposure to temperatures markedly higher than 250 deg. C. On the other hand, the view is strongly held in some quarters that pistons in aero engines sometimes attain a temperature sufficient to lead to the actual fusion of the aluminium-copper eutectic, and this would indicate a temperature exceeding 530 deg. C. It seems, however, from the nature of the alloys which have been more or less successfully used in such pistons, that the attainment of these temperatures must be exceptional.

A working temperature in the neighbourhood of 250 deg. C., however, represents a set of conditions very different from those applicable to a casting working at the ordinary temperature. The majority of aluminium alloys are found to lose their strength very rapidly with increasing temperature. This is the case to a surprising extent with all the alloys containing any appreciable quantity of zinc, and therefore alloys of that type and of the zinc-copper type must be excluded from use for pistons.

A long series of experiments were carried out at the National Physical Laboratory on the behaviour of various types of aluminium alloys under tensile tests at high temperatures, and these were confirmed by other workers, both at the Royal Aircraft Establishment, Farnborough, and in Professor Lea's laboratory, at Birmingham. It would occupy too much space to go into details of all these tests, but in Fig. 1 a series of graphs are given representing the tensile properties at various temperatures of five alloys. These include, in the first place, the "L 5" alloy, containing copper and zinc, which is seen to deteriorate very rapidly with rising temperature. We next have the alloy containing 12 per cent. of copper alone, and also an alloy which has proved very successful, up to a certain point, which has been developed at the Royal Aircraft Establishment. This contains 7 per cent. of copper, 1 per cent. of zinc, and 1 per cent. of tin. All these alloys, in varying degrees, show a decline of tensile

* Abstract from Cantor Lecture III., before the Royal Society Arts.

strength with rising temperature, although the two high copper alloys do not fall off so rapidly as the alloy containing zinc. The next alloy to be considered is one containing 14 per cent. of copper and 1 per cent. of manganese. This alloy, first developed at the National Physical Laboratory, shows the remarkable property that, up to a temperature of 250 deg. C., the tensile strength of castings increases instead of decreasing. Unfortunately this alloy proved somewhat difficult to cast, and was regarded as unduly brittle. Development was further hindered by the fact that, in the condition as cast, its thermal conductivity is distinctly lower than that of some of the others. Subsequent work has shown, however, that the reputation of this alloy for brittleness is scarcely well founded, while the thermal conductivity can be brought up to the level of that of the other alloys by a short period of annealing after casting. Some experimental pistons of this alloy have worked quite satisfactorily, and once aluminium founders have learnt to overcome the peculiarities of this material in casting, there is little doubt that it would prove a satisfactory and successful

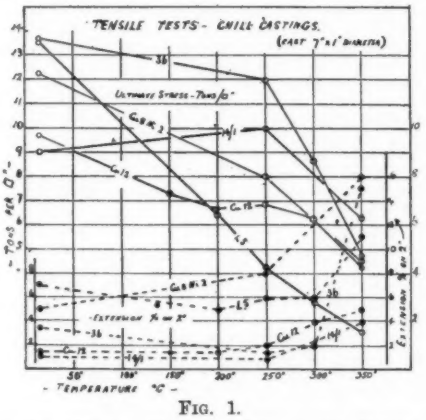



FIG. 1.

alloy for pistons. The last alloy on the diagram is that containing both copper and nickel (4/2/1½), to which reference has been made in the previous lecture. This alloy shows higher tensile properties at all temperatures up to 250 deg. C. than any of the others, and would therefore appear to be eminently suited for use in pistons. It was, unfortunately, only developed quite shortly before the close of the war, and therefore its adoption in practice was never carried out. It seems probable, however, that there is a very great future for this particular material, or, at all events, for alloys of that type.

Although aluminium pistons on the whole have proved eminently successful in aircraft engines, a certain amount of trouble has been experienced with them. In many cases this is no doubt due to failures of lubrication and similar defects. On the other hand, a whole class of cases of failure have been observed which are grouped under the name of "burning" of pistons. A burnt piston shows a roughened surface, which is sometimes deeply eroded, and in some cases, where the defects have gone very far, the piston may be entirely pierced at one point of its head. The exact nature of the action which takes place in these cases has not yet been fully elucidated. In some quarters it is thought that it is simply a question of the local fusion of the aluminium-copper eutectic and its expulsion, followed by the disintegration of the whole metal. If this is the case, the remedy lies in the use of alloys containing a smaller amount of the aluminium-copper compound. A more fundamental explanation seems to be, however, that, since alloys of the 12 per cent. copper type, or of the type containing 7 per cent. of copper, 1 per cent. of zinc, and 1 per cent. of tin have been so widely used for aero engine pistons, these pistons have been made of alloys not quite strong enough for their purpose at the temperatures to which they are exposed. This argument has been strenuously resisted by those who were anxious to avoid any change in the type of alloy used. There is, however, every hope that the adoption of alloys of the 4/2/1½ type will to a large extent eliminate the trouble from burnt pistons.

Another type of casting, which is also to some extent exposed to high temperatures, are the cylinder and cylinder blocks of aero engines. In the case of water-cooled engines, these are not exposed to anything like the temperatures which occur in the case of pistons, because the temperature of the cylinder casting is kept low by the circulating water, while the surface in contact with the exploding gases in the engine is generally provided in the shape of a steel liner. In air-cooled engines, however, even although a liner is still provided, the aluminium casting is liable to attain a considerable temperature, and power to withstand that temperature is necessary. In most cases, however, the castings required for cylinder purposes are of a very complicated character, involving a large amount of coring and somewhat difficult casting problems generally. In these circumstances alloys have generally been selected from the point of view of providing the greatest possible facilities to the founder, rather than from the point of view of securing the best possible physical properties for the engine. None the less, from the point of view of saving weight mainly, cylinder castings of aluminium alloys have proved very successful.

From the thermal point of view, however, the effect of substituting an aluminium alloy casting for the ordinary cast-iron cylinder of an aero engine, has been distinctly disappointing. The effect of the aluminium pistons in assisting in the removal of heat from the compression space of the engine having proved so very valuable, it was naturally hoped that similar high thermal conductivity in the cylinder walls would assist to a corresponding extent. Actually this has not been found to occur, and the gain in power and economy from the use of aluminium alloy cylinders has been comparatively small. To some extent this is probably due to the fact that a steel liner is usually interposed between the piston or the cylinder proper and the aluminium casting. The necessity for providing the interior of the cylinder with an iron or steel surface to take the wear of the piston is at the present time universally admitted. An engine has been run in which an aluminium alloy piston worked directly in a cylinder cast in the same material, but it is doubtful whether anyone would care to trust to the reliability of an engine constructed in that manner.

Unfortunately the behaviour of a steel liner inside an aluminium alloy casting is in many ways unsatisfactory. Owing to the fact that the aluminium casting expands much more rapidly with rising temperature than the liner itself, there is a tendency for the casting to expand out of contact with the liner. The result must be the development of a thermal discontinuity between the steel liner and the aluminium casting. This will result in a rise of temperature of the liner which will continue until the increased expansion of the liner, consequent upon such an additional rise of temperature, again brings it into approximate contact with the casting. The engine will therefore run, ultimately, in a condition of equilibrium, in which the temperature of the liner is considerably higher than that of the inner face of the aluminium alloy casting. Were it possible to provide the internal surface of an aluminium alloy cylinder with a hard wearing layer suitable for forming a cylinder wall and taking the wear of the piston, these disadvantages would be overcome. Apart from the question of temperature attained, however, there can be no doubt that the high thermal conductivity of the cylinder castings made in aluminium alloys has proved of considerable advantage in aero engines, particularly in the case of air-cooled engines. In these, when running at high powers, there is a strong tendency for distortion of the cylinders to take place, owing to the fact that the leading side of the cylinder in a rotary engine, or the forward side in a stationary engine, is better cooled by contact with the air than the other side. The result is an unequal expansion and a distortion of the cylinder which leads to bad fitting of the piston. The high conductivity of the aluminium alloy casting, however, equalises the temperature all around the cylinder in a much more satisfactory manner, and enables it to retain its circular section, thus preserving the efficiency of the piston.

Owing to the disappointing thermal results already indicated, aluminium alloy castings for cylinders have not found universal adoption even in aero engines. On the other hand, aluminium alloy cylinder heads have been widely used, and these can be employed without any lining, owing to the fact that they are not exposed to frictional contact with the pistons. Such cylinder heads, however, have to be provided with openings and seatings for the valves, and these again cannot be allowed to work direct on the aluminium alloy. As a rule this has been met by casting into the cylinder head casting suitable rings of steel to serve as valve seatings. In some cases these cast-in pieces have given a certain amount of trouble, but on the whole they can be used satisfactorily.

The question naturally arises whether other engine parts, particularly in aero engines, could not be made of aluminium alloys, and in this connection it is thought that a considerable field for the use of wrought, that is, rolled aluminium alloys may be opened up. In the first place, there are a large number of bolts and nuts in all aero engines, and in the aggregate the weight of these bolts and nuts when made in steel is very considerable. Their replacement by "duralumin" or "high tensile" alloys would undoubtedly effect a considerable saving. On the other hand, it must be borne in mind that, for these purposes, special steels having a very high tensile strength can be used.

A much more interesting, but also more difficult problem is the possible use of aluminium alloys for connecting rods. These are exposed to very severe alternating stresses, and at the same time, at one end at all events, they are also exposed to a high temperature. With a view to ascertaining the best alloy for this purpose, a series of alternating stress tests at high temperatures have been carried out. As a result, it has been found that the best alloy for such a purpose is undoubtedly the "4/2/1½" type, containing copper, nickel, and magnesium. Duralumin is found to come next in order of merit for this purpose, so far as alternating stress tests have indicated. There is, however, considerable difficulty in finding room for somewhat larger connecting rods in many engines, yet such an increase in size is probably essential if wrought aluminium alloys are to be used for that purpose. The development of a light alloy connecting rod for aero engines, and possibly for automobile engines generally, is therefore a matter which still lies in the future, although it is a development which is to be anticipated at an early date.

The properties required in the construction of rigid airship girders are obviously the maximum combination of strength with lightness. The form of strength required, however, is not mainly tensile strength, since failure in these complicated structures generally takes place by some form of buckling under a compression stress. The girders of the rigid airship are most liable to fail by buckling under compression, and such buckling may occur either in the girder as a whole, or in any small part of it. In order to ascertain the comparative behaviour of various alloys when rolled into the form of channel sections, such as are used in airship construction and exposed to compression stresses, a series of buckling tests have been carried out, using lengths of 6 in.

The results are given in Table II., where it will be seen that the new alloys show very considerable advantages over duralumin. The examples shown (at the meeting) of actual portions of girders constructed of these alloys are sufficient to prove that the materials

TABLE II.—*Compression Tests on "C" Type Channels.*

Selected channels .048 thick.
Six-inch lengths taken and ends "squared off" parallel to each other, and at 90° to C.L. of channel.
Tested with free ends between ball centres at centre of gravity of channel.
Length between ball centres, 7¼ inches.
Area, .089 square inches.

| Alloy. | Load tons. | Buckling stress, tons per sq. in. |
|---|---|---|
| 4/2/1½ alloy .. .. | 1.171 | 13.20 |
| | 1.259 | 14.16 |
| Duralumin (Vickers) .. | 0.992 | 11.15 |
| | 1.161 | 13.07 |
| 320 alloy .. .. | 1.469 | 16.50 |
| | 1.601 | 18.02 |
| H.T. alloy "G" .. | 1.629 | 18.31 |
| | 1.719 | 19.32 |
| H.T. alloy "F" .. | 1.862 | 20.97 |
| | 2.130 | 23.90 |
| H.T. alloy "E" .. | 2.020 | 22.72 |
| | 2.100 | 23.62 |

are quite capable of being produced and worked up into the condition required for these types of construction.

In the construction of all-metal aeroplane wings also, there is a field for light alloys. At the present moment an effort is being made to prove that high-tensile steel can be used with advantage in comparison with aluminium alloys. In view of the fact that the specific tenacities of the aluminium alloys are considerably higher than those of the best steels, this does not appear to be a correct solution. There is a further fact to be remembered, that in the use of a very strong but relatively heavy material like high-tensile steel, it will be necessary to employ it in extremely thin sections. There are obvious practical and structural reasons why this is very undesirable. Even from the point of view of corrosion, it is doubtful whether these very thin steel members would be any more reliable than those made of properly protected aluminium alloys.

The further development of the all-metal aeroplane would appear, therefore, to be dependent upon the proper utilisation of aluminium alloys, both for the construction of the spars and of the wing covering. The most obvious tendency to be followed in an all-metal construction would seem to be the replacement of the wooden spars and ribs and of the fabric covering by corresponding parts made of aluminium alloys. Considerable success has already been achieved in that direction, light alloy wing spars of strength and reliability at least as great as the best wooden spars have been produced and tested. With regard to the wing covering replacing fabric, it has been found possible at the National Physical Laboratory to roll down some of the strongest aluminium alloys into very thin sheets whose weight per square yard is not greater than that of doped fabric. This very thin sheet has a thickness of the order of .003 in., and therefore presents considerable difficulty both in course of manufacture and in handling. The actual problem of attachment has been solved by a particular device, which allows of the tightening of such metallic fabric by satisfactory mechanical means. There is, however, the very serious difficulty which applies to all sheet metal—that it has no very great resistance to tearing or ripping. In a fabric which is made of distinct fibres, these fibres are able, by a mutual displacement, to reinforce each other in supporting a tearing effort. In the case of metals, however, no such adjustment is possible, and it is consequently found that any continuous material is liable to tear with relative ease. The relative behaviour of fabrics which are heavily dressed, and in which, therefore, the various fibres are held in position so as to be unable to reinforce one another, and of soft fabrics where the fibres are able to move, in regard to tearing, illustrates what has just been said. The question whether resistance to ripping is of serious importance in aeroplane wings, particularly under peace conditions, where they are not liable to be ripped by flying fragments of projectiles, is a matter to be decided by actual experiment in flight.

As distinct from the tendency just discussed of replacing wooden wing structures by corresponding structures made of metal, there is an alternative course which offers considerable promise of success. In this the actual wing covering is to be regarded as part of the wing structure, and is to be made of such shape and dimensions as to be capable of supporting a share of the stresses which come upon the wing. A German all-metal aeroplane of the "Junker" type was provided with comparatively thick sheet metal wing covering having transverse corrugations, but it is anticipated that future developments in all-metal wing constructions will take a somewhat different direction.

Finally, reference may perhaps be made to another possible application of light aluminium alloys in engineering work. In the largest bridges and roofs it is well known that the greater part of the load which the structure has to bear consists of its own weight, the so-called live load or useful load, such as a railway train, representing only a small fraction of the weight of the structure itself. Actually, the longest possible span which can be constructed is limited by this consideration of the weight of the structure itself and the stresses which it imposes upon its members. The use of a material of very much lower density and of equal strength with mild steel, therefore, suggests the possibility of very greatly increasing the maximum possible span. There are, of course, not many situations in which these very huge spans would be required, but apart from that particular point, it must be borne in mind that the cost of a structure of large span is largely due to the fact that metal has to be provided mainly to bear the weight of the structure itself. It would certainly be possible to reduce this weight to a very considerable extent by replacing steel by aluminium alloys for those parts of the structure, at all events, which are responsible for the greatest development of stress in the remaining members. As an example of what is meant, the central portion of a cantilever bridge may be cited. This is really a small independent girder connecting the ends of the great cantilevers, and it is the weight of this central portion of the span which, to a large extent, governs the size and cost of the cantilevers themselves. By replacing this central span by a structure of aluminium alloy, a very large saving in the weight and cost of the steel constituting the rest of the structure could be effected, and it is, at all events, worth suggesting to bridge designers that the calculation of the relative cost of two structures, one made entirely of steel, and the other in which the central portion was made of a light alloy, is worth considering. Similar considerations also apply to roofs and other structures having exceptionally large span, where the weight of the structure itself enters largely into the cost of the material employed in building it. In the case of roofs, particularly, where the structure is protected from the action of the weather, the question of corrodibility does not enter seriously into the case. In any structure, however, the application of suitable protective coatings would be no more difficult in aluminium alloys than in the case of steel, and in the absence, at all events, of sea water, or spray derived from the sea, the relative permanence of an aluminium alloy structure and a steel structure, both properly protected, would not be very different.

# Manufacture of Rich Copper:

## ALUMINIUM ALLOYS, OR HARDENERS.

By Robert J. Anderson.

The use of rich copper-aluminium alloys for introducing copper into aluminium in the manufacture of No. 12 alloy or similar other light aluminium-copper alloys is an old practice, and it dates back to the early days of aluminium founding. As has been pointed out by the present writer, copper may be alloyed with aluminium in making up alloys for sand casting by two distinct methods: (1) By adding solid copper to liquid aluminium, and (2) by charging a rich copper-aluminium alloy with the aluminium. The majority of the aluminium foundries in the United States prefer to make up heats of No. 12 alloy by using a rich alloy containing about 50.0 per cent. copper and 50.0 per cent. aluminium. This rich alloy is referred to in foundry parlance as "hardener," "rich alloy," or "50:50," and for brevity it will be referred to in this Paper as 50:50 alloy. Another alloy preferred by a few is the eutectic containing 33.0 per cent. copper and 67.0 per cent. aluminium. A rich alloy containing 60.0 per cent. copper and 40.0 per cent. aluminium has also been suggested for the same purpose, but it has probably not been used commercially.

In the metallurgy of aluminium alloys, rich alloys are employed because they melt at temperatures lower than aluminium and, further, because they are brittle. The latter property permits them to be broken readily into small pieces, and thus to be weighed accurately.

### Methods Used Commercially.

There are three distinct methods in use for the manufacture of rich copper-aluminium alloys (50:50), of which the second is the most generally used; the two other methods are employed mainly in small foundries for making small lots of hardener for their own consumption. These methods are essentially carried out as follows: (1) By adding solid aluminium to liquid copper; (2) by adding liquid copper to liquid aluminium; and (3) by adding solid copper to liquid aluminium. The alloys may also be prepared by pouring liquid aluminium into liquid copper, but the opportunity for segregation is greatly increased in this way, and this is, in fact, a decidedly inadvisable method.

### Solid Aluminium to Liquid Copper.

Rich alloys, such as 50:50 alloy, are made in a few foundries by the addition of solid aluminium to liquid copper; this is, however, not a desirable procedure. One way of carrying out this method in the foundry is to melt the copper in a crucible and then add small amounts of cold aluminium from time to time with stirring until the requisite amount of aluminium has been put in. Too much aluminium cannot be added at one time, unless the copper is greatly superheated, or the entire melt will freeze. Ordinarily, it is necessary to maintain the temperature of the copper in the crucible by holding the pot in the furnace with the burners on. This is wasteful of fuel, and the method is slow and conducive to heavy dross losses. It is still used, however, in some small foundries in spite of its very obvious disadvantages.

### Liquid Copper to Liquid Aluminium.

The most favoured method for making rich alloys consists in melting the copper and aluminium separately and then pouring the liquid copper into the liquid aluminium. The resultant alloy is vigorously stirred to insure thorough alloying and prevent segregation; the alloy is then ingoted in the form of pigs of various convenient sizes from 10 to 60 lbs. or more. Where large lots are made at one time, it is good practice after melting the metals to pour the liquid aluminium into a large mixing vessel or container and then pour the copper into the aluminium. For convenience, the mixing vessel should be located near the furnace used for melting the copper.

As it is important to keep the temperature of the resultant alloy as low as possible so as to avoid heavy dross losses, the liquid aluminium should be chilled by adding cold aluminium ingot or notch bar. Thus only part of the aluminium to be used should be melted—say about two-thirds—and the remainder should be retained for use in lowering the temperature of the alloy during the time the copper is being put in and afterward.

It requires considerable skill to maintain the resultant alloy at a low temperature because of the considerable rise in temperature which takes place when liquid copper is added to liquid aluminium. The temperature rise is conducive to heavy dross losses, and it is best counteracted by the addition of sufficient cold aluminium in amount depending upon the temperature of the liquid aluminium and liquid copper. Experience, together with pyrometric measurements of the temperatures, will best indicate the correct procedure.

### Solid Copper to Liquid Aluminium.

This method for preparing rich alloys is similar to the method used for preparing No. 12 alloy by direct additions of solid copper to liquid aluminium. It is not used to any extent because foundries which prefer to add solid copper to liquid aluminium in the manufacture of No. 12 alloy do not use rich alloys. However, a few instances of the commercial use of this method have been reported. The method is carried out simply by melting the aluminium and then adding small amounts of light copper (sheet, punchings or other scrap) from time to time until the required amount of copper has been put in. After each addition of copper, the melt is stirred until the copper goes into solution. Dross losses are normally high in this method; furthermore, it is slow and not suitable for making large lots of 50:50 alloy.

### Liquid Aluminium to Liquid Copper.

No instances of pouring liquid aluminium into liquid copper as a commercial practice for the manufacture of 50:50 alloy have been reported, although this has been tried. A modification of this method is used, however, in some small foundries for making up small lots. In this modification, the copper is melted in a crucible, preferably in a stationary gas- or oil-fired furnace. A small notch bar of aluminium is held by tongs in the mouth of the furnace so that it gradually melts; as it melts, drops of liquid aluminium fall into the liquid copper. The resultant alloy is stirred from time to time until all the aluminium has been put in. This is a slow and expensive method, and conducive to high oxidation losses.

### Comparison of the Methods.

In the commercial manufacture of rich alloys of copper and aluminium, the consensus of opinion among the larger foundries is that liquid copper should be poured into liquid aluminium, with an endeavour at the same time to keep the temperature low by chilling the melt with additions of cold aluminium ingot; this should be accompanied by vigorous stirring. Where solid aluminium is added to liquid copper, there is danger of explosions from absorbed water in the aluminium, and in this method the aluminium should be preheated so as to drive out any water. This can be done by placing the notch bars on top of the furnace while the copper is melting. This method is conducive to heavy dross losses because of the high temperatures and the thermit reaction if much copper oxide is present (as there usually will be unless the copper is melted under charcoal). This method is also slow and wasteful of fuel; only small amounts of cold aluminium can be added at a time, otherwise the whole melt will freeze. In general, this method is undesirable and but little used.

When liquid copper is poured into liquid aluminium, the temperature of the resultant alloy may become high because of the normal heat of formation of the alloy, and, further, because of the thermit reaction which usually takes place. This is the only serious disadvantage in thus making the rich alloys, but it may be largely minimised by keeping the temperatures low by adding cold aluminium. This method is, in fact, the standard method for the manufacture of 50:50 alloy on a large scale, and while it is suitable for making both large and small lots, the method of adding solid copper to liquid aluminium may be preferable for small lots, say about 100 lbs. Comparative figures as to dross losses for the various methods will be given later.

### Properties of the Rich Alloys.

Alloys containing 33:67, 50:50, and 60:40 copper-aluminium are all white in colour, similar to aluminium, but the fractures are coarsely crystalline and bright. These alloys are all brittle, but the excessive brittleness diminishes with increasing aluminium content: thus, the 33:67 alloy is not so brittle as the 50:50 alloy, but the 60:40 alloy breaks readily if dropped on the floor. The 50:50 alloy is sufficiently brittle for all practical purposes, and if the rich alloys are too brittle, they powder excessively on breaking, thus causing dusting losses. Typical microstructures of these several alloys are shown in

* Abstracted from "Chem. and Met. Engineering," Sept. 29, 1920.

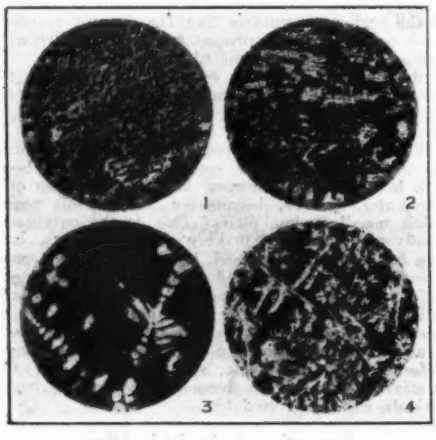
Figs. 1 to 4. The large interlocking crystals characteristic of the acicular structure formed when 50 : 50 alloy freezes uninterruptedly are conducive to brittleness, and this characteristic, together with the actual brittleness of the compound $CuAl_2$, makes the alloy easy to break.

The eutectic alloy (33Cu :67Al) melts at 540 deg. C., the 50 : 50 alloy at 575 deg. C., and the 60 : 40 alloy at 658 deg. C., practically the same temperatures as aluminium.

### Experiments with Rich Alloys.

In foundry practice, the rich alloys used for introducing copper into aluminium in the manufacture of No. 12 alloy and other such alloys include the 33 : 67 and 50 : 50 copper-aluminium alloys. The preparation of these rich alloys, as well as the 60 : 40 alloy, was studied in connection with the present investigation. A rich alloy containing 60.0 per cent. copper and 40.0 per cent. aluminium is very brittle, and it melts at about the same temperature as aluminium. In using this alloy, less of it is required to make up a heat of No. 12 alloy than when using either of the two other rich alloys. For these reasons, the preparation of the 60 : 40 alloy was also investigated.

The metals were melted in gas-fired crucible furnaces, using natural gas as the fuel and plumbago-clay crucibles. The resultant liquid alloys were stirred with an iron rod from which any oxide was carefully scraped after using. The alloys were poured into small pigs weighing from 4 to 6 lbs. each. Higher temperatures were taken with a platinum thermocouple protected by a quartz tube; and the lower temperatures were taken with a Wilson-Maeulen "pyod," using an indicating portable meter. The materials




employed consisted of heavy copper clippings, light copper punchings and aluminium ingot of the analysis given in the subjoined table :—

| Material. | Elements, per cent. Cu. | Fe. | Si. | Al* |
|---|---|---|---|---|
| Aluminium ingot .. .. | 0.25 | 0.39 | 0.31 | 99.05 |
| Light copper punchings .. | 99.89 | — | — | — |
| Heavy copper clippings .. | 99.92 | — | — | — |

* Aluminium, by difference.

The heavy copper used in experiments A-1, A-2, B-1, B-2, C-1, and C-2 was in the form of heavy clippings about ½ to 1 in. thick. The light copper used in experiments A-3, B-3 and C-3 was in the form of light punchings and clippings about 16 to 18 gauge. The cold materials were charged into hot crucibles at a mean temperature of 600 deg. C., but this is an approximate mean temperature, as the variations were from 400 to 700 deg. C.

It required, on the average, 27 mins. to heat a cold crucible to 600 deg. C., or a metered gas consumption of 2,800 to 2,900 cub. ft. The experiments are described in considerable detail and are summarised in Table I., and Table II. gives the chemical analyses of the rich alloys prepared.

TABLE II.—*Chemical Analyses of the Rich Alloys Prepared.*

| Alloy made in experiments. | Elements, per cent. Cu. | Fe. | Si. | Al* | Composition Aimed at |
|---|---|---|---|---|---|
| A–1 | 33.85 | 0.54 | 0.41 | 65.20 | 33:67 |
| A–2 | 32.53 | 0.51 | 0.34 | 66.62 | |
| A–3 | 32.78 | 0.44 | 0.32 | 66.46 | |
| B–1 | 49.27 | 0.43 | 0.34 | 49.96 | 50:50 |
| B–2 | 48.73 | 0.49 | 0.35 | 50.43 | |
| B–3 | 49.73 | 0.55 | 0.35 | 49.37 | |
| C–1 | 60.25 | 0.46 | 0.31 | 38.92 | 60:40 |
| C–2 | 59.57 | 0.58 | 0.35 | 39.52 | |
| C–3 | 58.04 | 0.55 | 0.39 | 41.02 | |

* Aluminium by difference.

TABLE I.—*Summary of the Rich Alloy Experiments.*

| Experiment. | Wt. copper, lb. | Wt. Aluminium, lb. | Time required to melt copper, min.* | Time required to melt aluminium, min.* | Temperature copper, deg. C. | Temperature, aluminium, deg. C. | Highest observed Temperature of alloy, deg. C.† | Final temperature of alloy, deg. C. | Alloy poured at, deg. C. | Wt. pigs poured, lb. | Wt. dross recovered, lb. | Shrinkage, lb. | Total loss, per cent. | Metal oxidized, per cent.‡ | Total gas consumption, cu. ft.§ | Cost gas used, dollars.¶ | Alloy made. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A–1 | 8.25 | 16.75 | 26.0 | — | 1,155 | 25 | — | 705 | 700 | 24.00 | 0.85 | 0.15 | 4.0 | 1.80 | 3,860 | 1.16 | 33:67 |
| A–2 | 8.25 | 16.75 | 28.0 | 27.0 | 1,125 | 880 | 1,065 | 1,065 | 1,040 | 24.15 | 0.65 | 0.20 | 3.4 | 1.38 | 5,915 | 1.77 | 33:67 |
| A–3 | 8.25 | 16.75 | — | 26.0 | 25 | 820 | 925 | 890 | 874 | 23.55 | 1.15 | 0.30 | 5.8 | 2.44 | 2,730 | 0.82 | 33:67 |
| B–1 | 12.50 | 12.50 | 38.0 | — | 1,120 | 25 | 1,225 | 685 | 677 | 23.75 | 1.00 | 0.25 | 5.0 | 2.12 | 4,730 | 1.42 | 50:50 |
| B–2 | 12.50 | 12.50 | 40.0 | 26.0 | 1,203 | 705 | 1,085 | 1,080 | 1,061 | 23.50 | 1.00 | 0.50 | 6.0 | 2.12 | 7,130 | 2.14 | 50.50 |
| B–3 | 12.50 | 12.50 | — | 24.0 | 25 | 690 | 906 | 900 | 887 | 22.25 | 2.25 | 0.50 | 11.0 | 4.77 | 3,145 | 0.94 | 50:50 |
| C–1 | 15.00 | 10.00 | 42.0 | — | 1,170 | 25 | 1,278 | 860 | 842 | 22.60 | 2.00 | 0.40 | 9.6 | 4.24 | 4,620 | 1.39 | 60:40 |
| C–2 | 15.00 | 10.00 | 43.0 | 21.0 | 1,205 | 750 | 1,256 | 1,225 | 1,190 | 23.50 | 1.00 | 0.50 | 6.0 | 2.12 | 6,935 | 2.08 | 60:40 |
| C–3 | 15.00 | 10.00 | — | 22.0 | 25 | 783 | 855 | 809 | 787 | 22.15 | 2.55 | 0.30 | 11.4 | 5.41 | 3,360 | 1.01 | 60:40 |

* Solid metal temperatures are taken as room temperature—*i.e.*, 25 deg. C.
† The figures indicate the observed highest temperatures; higher temperatures may have been attained, but they were not observed.
‡ Based on the assumption that dross is equivalent to $Al_2O_3$, containing about 53.0 per cent. aluminium.
§ The copper-melting furnace consumed 110.0 cu. ft. per min., and the aluminium-melting furnace 105.0 cu. ft. per min.; in some cases additional gas was used in addition to that required for melting.
¶ Based on gas at 80.30 per 1,000 cu. ft.

### Discussion of the Experiments.

These experiments have afforded some interesting data with regard to the temperature rise noted by other observers when solid aluminium is added to liquid copper. While most of the melts were made under such conditions that copper oxide was doubtless present in the liquid copper, some showed that a temperature rise is obtained even when aluminium is added to copper melted under charcoal. Others indicated that the temperature rise observed on adding solid copper to liquid aluminium continues with successive additions. These data prove that part of the temperature rise is due to oxidation of the aluminium and part of it to the heat of formation of the alloys. Practically, therefore, it is advisable to employ oxygen-free copper for making rich alloys, and the copper should either be deoxidised before pouring into the aluminium or be melted under reducing conditions so as to prevent the presence of any considerable amount of cuprous oxide in the copper bath.

Moreover, from a practical standpoint, it is desirable to hold dross losses low in the manufacture of rich alloys as well as keep the melting costs down. By the methods employed in the present experiments, the melting costs were highest for the three alloys when the method of pouring the liquid copper into liquid aluminium was employed. This is to be expected, because two different furnaces were running in this method, one on copper and the other on aluminium. In the other methods, where one solid metal is added to another liquid metal, some saving is had by taking advantage of the residual heat in the crucibles and furnace. The total losses (made up of dross plus shrinkage) and the dross losses were lowest in the case of the method of pouring copper into liquid aluminium. These losses were very heavy in the method where solid copper was added to liquid aluminium.

In considering the dross and shrinkage losses in Table I., it should be borne in mind that the experi-

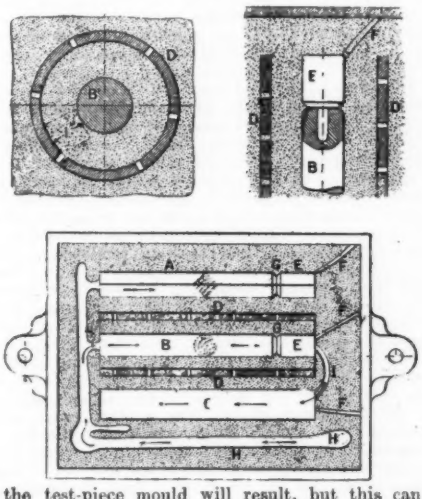
ments were carried out on a small scale, 25-lb. charges being used. The relative order of the losses in preparing the rich alloys by the different methods is correct, but the actual figures are not representative of large-scale practice. On preparing the alloys on a large scale, the losses would be considerably lower. Moreover, it should be pointed out that ordinarily the dross is not entirely loss in commercial practice, because a considerable recovery of metal would be made by running down the dross and skimmings.

The conclusion arrived at from these experiments is that the most desirable and best way of making any of the rich alloys is to melt the aluminium and copper separately and pour the copper into the aluminium. On a large scale, where, say, 2,000 lbs. of the 50 : 50 alloy is made at a time, a satisfactory procedure is to melt about one-third of the total aluminium in an iron pot or other suitable vessel; after it is melted, cold pigs from part of the remaining aluminium should be thrown in to cool the metal. Here, solid aluminium would be floating around in the liquid metal. The copper should have been previously melted separately, and with the aluminium in the above condition, about one-fourth of the copper should be poured in The addition of the copper will raise the temperature of the aluminium, but the resultant alloy may be cooled down by throwing in more pigs of cold aluminium. Then about one-fourth or more additional copper should be added and then more cold aluminium, and so on until the two melts have been properly alloyed. The alloy should be thoroughly stirred during the additions to facilitate alloying, and should be stirred well on pouring or ladling out into pigs. These directions are admittedly only very general, and the quantities of the several additions will vary considerably with the temperatures. The manufacture of rich alloys should be carried out under the supervision of a competent melter, and the use of pyrometers for frequent temperature measurements will be of value. In any event, the effort should be made to keep the temperatures as low as is consistent with rapid alloying and not allowing the alloy to freeze in the mixing vessel.

## Moulding Tensile and Shock Test-pieces.

When cast-iron tensile test-pieces are cast direct they invariably show a lower maximum stress than that of the material from which they are cast. A recent issue of the "Fonderie Moderne" advocates the following method :—Referring to Fig. I., the method consists in allowing a quantity of metal to pass through the mould (B) and channel (I.) into the reservoir (C) for the purpose of pre-heating the true mould.

Unless special precautions are taken a deformation




of the test-piece mould will result, but this can be avoided by the introduction of a perforated cylinder (D). The pattern of the tensile test-piece is made of steel, which consists of two parts, joined together by means of a pin. This allows of the withdrawal of the pattern from both ends, and at the same time leaves a neck for breaking off the riser (E). The mould should be thoroughly dried, and the metal must be hot and clean. The runner is formed with a white metal pattern, and the whole is built up on a plaster base. Vent holes (F) are necessary to carry off the air. A shock test-piece (A) is cast at the same time. The best results are obtained by inclining the mould from 30 to 45 deg. and pouring the steel from the runner (H).

## The Manufacture of Ferro-Manganese in the Electric Furnace.

The high prices obtained for ferro-manganese during the past five years has greatly stimulated its manufacture in the electric furnace, and the utilisation of low-grade manganese ores that could not be successfully smelted in the blast-furnace. Under normal conditions manganese ores containing less than 40 per cent. manganese, and above 15 per cent. silica, cannot be economically smelted in the blast-furnace, but they have been successfully smelted in the electric furnace.

The type of electric furnace which is now meeting with most favour is of the stationary open-top type, 3-phase, 3-electrode type, and the furnaces range in size from 300 kw. to 4,000 kw., lined with carbon and magnesite. Old electrode stubs are usually set upright in the bottom of the furnace and along the sides, the cavities being filled with crushed electrodes, mixed with magnesite and hot tar, the whole mass being tamped into shape round a form set in the centre of the furnace shell, this form being the size and shape of the desired melting chamber. Linings of the above character have proved very satisfactory and give a long life to the furnace shell.

The usual practice is to make a mix of ore, lime, rich slag, coke and coal, or some operators prefer coal or coke used separately. The mixture is charged by hand direct into the top of the furnace and distributed as much as possible between the electrodes. As the mix is slowly melted down, more is charged on the top, the object being to keep the furnace heat covered and to protect the electrodes and buss bars as much as possible from the extreme heat. The furnaces are tapped every two hours into settlers or cast-iron or steel slag-pots on movable trucks, and as soon as the metal and slag have cooled sufficiently to be dumped and cleaned, the adhering slag and coating of fireclay are cleaned off. The clean metal is then weighed and taken to the store-house and the rich slag and dirty metal are returned to the furnace. It has been found necessary to give the slag pots a coating or wash of fireclay and water to prevent the hot metal when first tapped from burning a hole through the sides of the pot. This wash is applied as soon as the metal and slag have been dumped from the pots, and while they are still hot, it soon dries and the pots are then ready for the next furnace tap. Cast-steel pots have given great satisfaction, and they outlast at least 3 cast-iron pots, although the cost of the steel pots is higher in the first instance.

The recovery of the total manganese, as contained in the cleaned metal does not usually exceed 70 per cent. of the total manganese charged into the furnace. If the manganese ore charged into the furnace, does not contain sufficient iron, when it is all reduced, to make an alloy containing 80 per cent. manganese, it is the usual practice to charge iron ore, or steel turnings to the furnace to reduce the percentage of manganese to approximately 80 per cent. as the ferro-alloy manufacturer is not usually paid for any manganese contained in the alloy over 80 per cent.

The cost of electric furnace ferro-manganese is much higher than the blast-furnace product. The average cost over a period of six months for a 1,250 kw. furnace was £54 per gross ton. The cost being divided between as follows :—

| | | | | | | |
|---|---|---|---|---|---|---|
| Manganese ore cost per ton of ferro-manganese produced ... ... ... ... ... | | | | £23 | 17 | 6 |
| Electrodes | do. | do. | do. | 4 | 3 | 0 |
| Coal and coke | do. | do. | do. | 2 | 0 | 0 |
| Miscellaneous materials used | | | do. | 0 | 15 | 0 |
| Total supplies used | | do. | do. | £30 | 15 | 6 |
| Labour | do. | do. | do. | 14 | 3 | 6 |
| Electric power | do. | do. | do. | 9 | 1 | 0 |
| | | | | £54 | 0 | 0 |

Power consumption per pound of alloy, 2.5 kw.

**GAS FROM STRAW.** — A gas obtained by the destructive distillation of wheat and other straw is now being produced on a small scale at the experimental farm in the United States under the control of the Department of Agriculture. According to "The Engineer," several valuable by-products are obtained, such as carbon residue, suitable for the manufacture of lampblack, potash, phosphates, and nitrogenous compounds. The tar and ammoniacal liquors are similar to those formed by the destructive distillation of coal. The results obtained are held to be sufficient to warrant further large scale investigation as to the possibility of designing a plant to produce the gas in sufficient quantities to allow a farmer to supply light and heat for his house, power for his stationary engines, and possibly for his tractor, from a small individual outfit.

XUM

# Refractories for Electric Furnaces.*

By W. J. Rees, R.I.C.

As a preliminary to the discussion of the most desirable refractory materials to use in the construction and maintenance of electric furnaces, it will be advantageous to consider certain fundamental data relative to the physical and chemical properties of the available materials.

The desirable properties of a dependable refractory for an electric furnace lining are:—(1) A high melting point and strength at high temperature; (2) uniformity of volume; (3) high resistance to abrupt temperature changes; (4) high resistance to slag and metal attack; (5) high resistance to abrasion of hot gases; (6) low electrical conductivity; (7) low specific heat.

*Fusion Points.*—The following table (Table I.) shows the effect of pressure on the temperature at which four different firebricks deformed:—

TABLE I.—*Influence of Pressure on Fusion Points on Firebricks.*

| No. | Normal melting point. | Under load of 50 lbs. per sq. in. | Under load of 75 lbs. per sq. in. |
|---|---|---|---|
| | Deg. C. | Deg. C. | Deg. C. |
| 1 | 1650 | 1435 | 1380 |
| 2 | 1630 | 1410 | 1350 |
| 3 | 1580 | 1380 | 1350 |
| 4 | 1690 | 1435 | 1410 |

Table II. shows the behaviour of the refractories under a load of 50 lbs. per sq. in.:—

TABLE II.—*Influence of Pressure on Various Refractories.*

| Type of brick. | Pressure 50 lbs. per sq. in. | |
|---|---|---|
| | | Deg. C. |
| Fireclay .. | Deforms at .. .. | 1400 |
| Silica .. | Rigid to .. .. | 1500 |
| | Deforms or shears at .. | 1600—1650 |
| Magnesite .. | Shears at .. .. | 1350—1550 |
| Bauxite .. | Deforms at .. .. | 1350—1500 |
| Chrome .. | Deforms or shears at .. | 1300—1400 |
| Zirconia .. | Deforms at .. .. | 1450—1600 |
| Carborundum . | Rigid at .. .. | 1650 |

*Specific Gravity.*—The specific gravity of the refractory is only of importance in so far as it affects the weight of the furnace lining and the necessary strength of the framework. A lower value (2.3) will be obtained by hard burning and effectual inversion of the silica to the form of lower density; with the other materials the higher value (2.45) will be obtained by high temperature burning.

*Specific Heat.*—Increasing attention is being given to this important property of refractories which in all cases increases with the temperature. Further investigations of this constant will be of considerable value to users of refractories.

*Thermal Conductivity.* — The thermal conductivity will obviously be very greatly influenced by the porosity of the material. This probably explains the lack of concordance of some of the published determinations.

*Electrical Conductivity.*—Zirconia has a very low thermal conductivity at high temperatures. The growth in the industrial applications of electric furnaces has brought with it a demand for information as to the electrical resistivity of the refractories used in their construction. The resistivity will vary with the texture of the brick as well as with its chemical composition. In the case of silica bricks also, for instance, the proportion of bonding material used will affect considerably the resistivity of the brick. It is obviously desirable therefore that when resistivity determinations are published they should be accompanied by data as to the chemical composition, porosity, etc., of the materials tested.

*Resistance to Temperature Changes.*—The stability under changes of temperature will be dependent on the thermal properties of the refractory material and on the structure of the manufactured brick or block. Bricks with an open texture will be more resistant to abrupt temperature changes than those with a fine grained close texture. Silica bricks and siliceous fireclay bricks must of course be heated slowly, up to a red heat, as also must magnesia and chrome, if spalling is to be avoided. Aluminous firebricks, an electric furnace product, are only slightly affected by abrupt temperature changes, except that in the case of very dense fine-grained firebricks care must be exercised in heating in order to avoid cracking or crizzling.

The behaviour of the various types of refractory under the conditions of electric furnace practice will now be considered.

*Fireclay.*—In metallurgical operations it is, generally speaking, desirable to use fireclay refractories wherever they are likely to give the necessary service. A good range, from the siliceous to the aluminous firebrick, is generally available at a moderate price, and, on the whole, the bricks require less care in handling than any other refractory material. Owing to the high temperatures involved in the melting of steel, however, only the most refractory firebricks are of any service; but for non-ferrous metal melting advantage may be taken of the desirable properties of the less refractory firebricks. As indicated by the pressure tests in Table II., it is undesirable to heat to a high temperature more than one face of any refractory which is carrying load—with the possible exception of silica brick. Useful results have been obtained in practice, particularly in small furnaces, with roofs of aluminous firebrick, such as those made from the Ayrshire bauxitic clays or shales. With any type of firebrick, used near its limiting temperature, it is desirable to avoid insulation, even of the fortuitous kind, from the accumulation of dust. Advantages may be obtained by the use of properly designed water-cooling plates, as is instanced by their successful use in the hot zones of blast furnaces and their extended use during the last year or two in other metallurgical and glass-making furnaces. Well-burned brick is essential in order to obviate failures from excessive after-contraction, and bricks which tend to "bloat" at moderately high temperatures must be avoided.

*Silica Bricks.* — The fusion point of good silica brick is approximately the same as that of a first-grade firebrick, but owing to its greater rigidity at temperatures within 100 deg. or so of its fusion point and its relatively higher thermal conductivity at high temperatures, it gives better service in roofs than firebrick under normal conditions. It is advantageous to relieve the strain which develops when the roof is heated and to re-impose pressure when it is necessary to cool it. Much spalling loss can thus be avoided. Generally speaking, loss by spalling is much less in small silica shapes than in the larger heavier blocks as the strains developed in the latter during the heating up of the furnace are decidedly greater. It is consequently desirable to avoid so far as possible the use of large silica blocks. It is essential that silica brick should be well burned. The texture should be moderately fine and should be uniform throughout the brick. A well-graded lime-bonded brick, adequately burned so as to secure the conversion of a good proportion of the quartz to tridymite or crystobalite should give satisfactory service if properly used under normal conditions.

*Magnesite.*—The high fusion point, high thermal conductivity, and slag and metal resisting properties of magnesite brick render it of particular value in electric furnace practice. Careful treatment of the bricks is necessary because of their spalling tendencies. Both the bricks and the grain magnesite used in basic hearths and bottoms should be burned to a specific gravity of not less than 3.4 to 3.6. The presence of such impurities as ferric oxide (either natural or added) facilitates the effective sintering of the magnesia and the production of a material having very small after-contraction and highly resistant to slaking. Experiments carried out by McDowell and Howe indicated that the magnesites of low lime content were most resistant to slag attack, but it seems probable that if the material is adequately sintered, has sufficient ferruginous matter present, and is low in silica content, satisfactory service can be obtained from magnesites of lime content up 17 or 18 per cent. The lime content of a magnesite hearth is frequently raised by the 10 or 12 per cent. of slag admixed. Magnesite brick should of course always be laid dry, as it is disintegrated by the action of steam. Magnesia is reduced by carbon at 1,700 to 1,800 deg. C., and is attacked by melts containing silicon or phosphorus. Metalkase magnesite bricks, which consist of a soft-steel box rammed hard with dead-burned magnesite, are being used to a large extent for bottoms and side walls. On heating, the case melts and a practically jointless surface is secured which is much less sensitive to spalling than magnesite brick.

*Dolomite.*—Dead-burned dolomite is largely used for the making of basic bottoms. Occasionally mixtures

* Paper read before the Sheffield Society of Metallurgists and Metallurgical Chemists.

of magnesite and dolomite with a small quantity of slag are used. It seems very probable that not only better keeping properties, but also increased resistance to slag attack can be given to dolomite by the addition of slag or other material to the raw dolomite which is then sintered in a modern type of high temperature kiln. It may also be possible from such material to make satisfactory dolomite bricks and thus effect considerable economies in furnace construction and maintenance.

*Chrome.*—The high fusion point, high thermal conductivity and resistance to both acid and basic slags of chrome brick render it suitable for use at the slag line, though there is some slight danger of contamination of the metal with chromium. Chrome brick or mortar is used to a considerable extent as a separatory layer between acid and basic refractories in high temperature furnaces. Its use between silica and magnesite is however being largely discontinued.

*Zirconia.*—Zirconia has up to the present been disappointing as a refractory. Its high fusion point and high resistance to the attack of many slags coupled with a very low thermal conductivity, point to valuable uses for it, but its tendency to form carbides at high temperature together with its high shrinkage have militated against its use. These disadvantages may possibly be overcome by the use of purified materials calcined at high temperatures, so as to eliminate subsequent shrinkage, with a satisfactory bond. The use of zirconium silicate has been suggested. It has a melting point of 2,500 deg. C., but is very difficult to bond.

Staley has suggested the use of fused zircon, which is not subject to volume changes. It has a low coefficient of expansion, low thermal conductivity, and high electrical resistivity, but it attacked by basic slags. Despite the disappointments which have so far attended its use, zirconia has so many valuable characteristics that it is important in the interests of electric furnace development that the efforts to overcome its defects should be continued.

*Bauxite.*—The difficulty in the uses of bauxite is its high shrinkage. A well-bonded brick made from completely shrunk bauxite would be a valuable neutral refractory. The successful use of such a material for furnace bottoms has been reported

*Alundum.* — Alundum and other forms of fused alumina have distinct possibilities because of their high refractoriness, high heat conductivity, and constancy of volume at high temperatures. Reliable information as to their behaviour in contact with slags is not at present available.

*Carborundum* is at the present time being rather boomed as a refractory. It undoubtedly has many valuable properties, but is severely attacked by slags and iron or steel. Under oxidising conditions it begins to dissociate at 1,500 deg. C., and under reducing conditions at 1,700 deg. C. It may be of considerable service in non-ferrous practice and for situations in ferrous furnaces where it is out of possible contact with metal or slag. Its refractoriness is such that it is possible to back it with insulating bricks and so reduce heat losses.

*Composite Bricks* —A number of attempts have been made to produce bricks with a face of one of the expensive highly refractory materials such as zirconia, magnesite, chromite, or carborundum, with a backing of a cheaper refractory, but they have not up to the present been successful, mainly because of the spalling of the face due to the strains set up by differential thermal expansions.

*Possible New Refractories.*—In a Paper on "The Common Refractory Oxides," presented to the Faraday Society Symposium on Refractories in 1917, R. B. Sosman in discussing the $SiO_2 : Al_2O_3$ equilibrium diagram suggested the probable usefulness of synthetic sillimanite, the melting point of which is at 1,820 deg. C. Such material could be made commercially by admixture of bauxite and fireclay, with subsequent sintering at high temperature. The system $MgO : Al_2O_3$ was also referred to, and attention directed to the compound spinel ($MgAl_2O_4$). The melting point of this compound is very high (2,135 deg. C.), and as its eutectics, with its two component oxides, have only slightly lower melting points, particular care need not be exercised to make it up in the exact proportion $MgO : Al_2O_3$. The well-mixed oxides will begin to form the compound at a temperature well below its melting point, and this chemical reaction would result in very effective bonding.

Both sellimanite and spinel would remain rigid almost up to their melting points, as they have definite melting points, and not a melting or softening range like fireclay.

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**BLOWERS.**—"The Use of Positive Displacement Blowers in Cupola Practice" was the subject of a paper read by Prof. W. Trinks at the recent American Foundrymen's Convention held at Columbus. Discussing the different characteristics of positive displacement and centrifugal or fan blowers, the author stated that for a given change of pressure the delivery of a centrifugal machine varies much more than that of a displacement blower.

# Setting and Sharpening Saws.

By JAMES EDGAR.

It is surprising how many patternmakers there are who cannot sharpen either their hand saws or the band and circular saws. Probably this may be attributed in part to the fact that in most big patternshops there is either a patternmaker or a woodmachinist whose sole duty it is to keep the machines in order, and who is generally willing to touch up crosscut and rip saws. And in addition, special tools, saw sets and files, and a special vice are almost absolutely necessary. Nevertheless, every patternmaker should be able to keep his saws in good condition. Saws are not finishing tools like chisels and gouges, but when sharp they certainly save much time and energy. Even in the few shops which have a swinging saw at the woodshed, there are many times when it is necessary to fall back on the hand saw, and in small shops where there is not sufficient work for a machinist, although it should be one man's duty to sharpen the various machines, all ought to be qualified if called on to do the work.

The set on a saw should really depend on the class of timber which is being used; for instance, if it is hard and dry less set is required than if it is soft and wet. As the patternmaker invariably works in yellow pine, his saw should have considerable set. Setting a saw is, of course, bending every alternate tooth to one side and the remaining teeth to the other. With practice this can be very well done with a hammer and punch, and many old craftsmen will not adopt the newer method of using a saw set, but there can be no doubt that this is the better method, and especially so in the hands of an experienced man.

A very common form of saw set is shown in Fig. 1. The disc on which figures representing the number of teeth per inch of the saw are marked is turned round

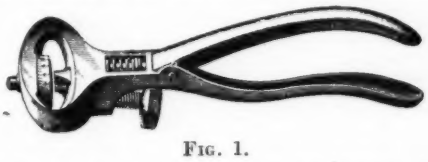

FIG. 1.

till the five, if five teeth per inch are required, is in front of the plunger. The amount of set is gauged by the screw underneath the bottom handle. When the handles are gripped and pressed the plunger is moved forward against the disc, and when the grip is relaxed the spring brings back the plunger. The notch seen at the bottom of the illustration rests on the top of the saw clamp when one tooth stands before the plunger. The adjusting screw is set, the handles pressed and the result inspected. It may be necessary to alter the set once or twice. When the correct set is obtained each alternate tooth is done, after which the saw is reversed and the remaining teeth set.

In sharpening a handsaw care should be taken that the teeth are all level, and this is best done by passing a file over them while the saw is held firmly in the vice. Sometimes a special tool called a jointer is made for this purpose. This is simply a file, set into a block of wood at right angles to its face. The wood is then moved along the face of the saw with the file pressing against the teeth. When a saw is put in the clamp, only the teeth should project above the jaws. A three-cornered tapered file is the most suitable, and the angle at which it is held depends on whether the saw is a rip saw or a cross cut, and also whether for hard or soft wood. For a rip saw, the file should be held at right angles to the face of the saw, but for a crosscut the angle varies. After one has sharpened a saw two or three times there is no difficulty on deciding the angle of the teeth. The experienced man is able to file the teeth correctly at one operation, but the beginner at saw sharpening should reverse it two or three times. Furthermore, a good job cannot be made with short and erratic strokes of the file. It improves the result if an oilstone is rubbed lightly along the sides of the teeth as it makes quite sure that the points are in line.

When setting circular and bandsaws, the same precaution must be taken to get all the teeth of the same length, otherwise the saw will be subjected to unequal strains. This is more easily done with a circular or bandsaw than with a hand saw, because all that is necessary is to start the saw and hold a piece of sandstone against the teeth. As in the case of the handsaw there is no hard and fast rule as to the angle of the teeth. On crosscut saws the level should not be carried down to the roots of the teeth, but only about half-way down, as all the cutting is done by the points. After the saw has been sharpened several times, a groove is formed with the file at the roots of the teeth. This is ruinous to the saw and also dangerous, as there is a tendency to crack. This is best avoided by filing the roots of the teeth with a round file.

XUM

# Trade Talk.

THE employés of the Blantyre Engineering Company, Limited, contributed £57 during last year to charitable institutions.

A DEPARTMENTAL Committee has been appointed by the Secretary for Mines to consider improvements in miners' camps.

AN interesting paper on "Recent Developments in Transmission" was real before the Institution of Automobile Engineers by Capt S. Bramley-Moore, on the 12th inst.

AT a meeting of the River Tyne Commissioners this week it was reported that coal shipments from the river last year were 10,252,000 tons, against 12,052,000 tons in 1919 and 19,992,000 tons in 1913.

ACCORDING to recent inquiry, Russia requires yearly 850,000 new ploughs, 85,000 reaping machines, 17,000 threshing machines, 340,000 drill ploughs, 850,000 winnowing machines, and over a million each of scythes and sickles.

IN a discussion of Germany's currency problem it is urged that the annual budget must be made to balance, and that no expenditure of any kind should be sanctioned which is not covered in advance by the requisite revenue.

AN invention for the production of rust-free steel is reported, which will be exploited by a large Norwegian company at Tyrre, in the neighbourhood of Hardanger. The rust-free steel is said to be no more expensive than ordinary steel.

THE ballot of the members of the Amalgamated Engineering Union for or against a levy of 1s. per member for thirteen weeks to provide extra benefit for unemployed members has been carried by a considerable majority.

THE contract for a Donaldson liner, which was being built by Messrs. Vickers at Barrow, has been cancelled, although work has been in progress on the vessel for six months. This is due to the high cost of production.

THERE is a big slump in the patent fuel export trade, of which Bristol Channel ports hold practically a monopoly. So serious is the position that manufacturers have applied for a reduction of 20 per cent. in wages, and a joint meeting is to be held at Cardiff on Monday to consider the demand.

FOR the post of general secretary of the Amalgamated Engineers' Union, vacant by the retirement of Mr. Tom Mann, there are now two candidates left after the first ballot—Messrs. J. Kaylor (Coventry) and Mr. A. H. Smethurst (Oldham). The result will be decided by a final ballot.

A BERLIN message states that the Rhineland Socialist paper, the "Ruhr," announces that the miners of the Ruhr Basin have decided, by depriving Bavaria of coal if necessary, to enforce the disarmament of the civic guard. This decision has been communicated to the Minister of the Interior.

A NEW passenger steamer for the Great Eastern Railway, which is to be used on the Harwich-Antwerp service, was launched at the Walker yard of Sir W. G. Armstrong, Whitworth & Company, Limited, on the 6th inst., by Mrs. Kenneth Foster, wife of Mr. J. Kenneth Foster, a director of the G.E.R. Company.

DR. MACNAMARA visited the training centres for ex-servicemen in Edinburgh last week. In the course of an address he said they had run into heavy weather of industrial depression, and there was natural anxiety lest they should train men who, at the end of their training, might be unable to get employment, but in one or two crafts they might take more risks.

IT is reported that negotiations are in progress between the United States Mail Steamship Company and German shipyards for the re-conditioning and overhauling of many passenger boats which have been chartered from the United States Shipping Board. A sum of $35,000,000 is stated to be involved on the proposed contracts.

LLOYD'S REGISTER shipbuilding returns for the quarter ended December 31 last state that the merchant tonnage building in the United Kingdom at the end of December, 1920, viz., 3,708,916 tons, although considerably more than the work which was in hand twelve months ago, shows a decrease, as compared with September, 1920.

ORDERS have been issued for the White Star liner "Baltic" to be taken off service and sent to the Belfast yard of Messrs. Harland & Wolff, Limited, for complete re-conditioning. Her place has been taken by the "Cedric," which has just been completed. Shipbuilding on the Lagan is unaffected by the joiners' strike, and prospects for the year are very good.

THE report of the Judges' Committee on the Air Ministry competitions held during last August and September for the purpose of ascertaining the best types of aeroplanes, which has now been issued, states that the magnetos fitted to the competing machines were all of British design and construction, and that the manufacturers are now abreast of any of their foreign rivals.

IN a recent interview, Mr. D. B. Morison, chairman and managing director of Messrs. Richardsons, Westgarth & Company's marine engineering works at West Hartlepool, said unemployment was rapidly increasing in steel manufacture and in shipbuilding and marine engineering. Stagnation must continue and unemployment increase until goods could be delivered at a price which the consumer could pay.

A LARGE majority of the shareholders of the British Mannesmann Tube Company, Limited, having accepted the offer of Baldwins, Limited, to effect an exchange of shares, the directors of both companies have decided to complete the provisional agreement, establishing a fusion of interests. Meetings of the shareholders of Baldwins, Limited, will be called at an early date to sanction the necessary increase of capital.

So serious is the position of shipbuilding in Canada reported that in the words of the managing director of the Canadian Vickers Company, of Montreal, 40 per cent of the shipyards contemplate closing down, and unless conditions change most of the others will soon follow. The completion of the Government's shipbuilding programme by the spring must mean an end of business for all but half a dozen of the larger and stronger companies.

THE annual meeting of the Sound Currency Association, which aims at the restoration of the gold standard, will be held at the Cannon Street Hotel on Tuesday, January 25, at 2.30 p.m. Mr. D. M. Mason will preside, and the speakers will include Professor Edwin Cannan, Lord Farrer, Mr. J. M. Hogge, M.P., Sir Charles Hobhouse, and Mr. W. F. Spalding. The meeting is open to the public, who are cordially invited to attend.

A LITTLE time ago some of the workmen tenants of Messrs. Guest, Keen & Nettlefolds, Limited, expressed a desire to purchase their dwellings in Dowlais, and as a result the firm has decided to offer the whole of their interests in about 1,000 houses at moderate terms to the occupiers, and at the same time dispose of a large number of licensed and business premises in the same town, which are to be offered for sale by auction on the 18th inst.

IT is officially announced that the German coal production amounted in December last to 8,200,000 tons, thus showing a difference from the figure of 7,096,130 tons previously given as the output of the Rhenish Westphalian coalfield. It is added that this brings the total yield for the year to approximately 88,000,000 tons, or 26,200,000 less than in 1913, notwithstanding the fact that the number of miners employed has increased by almost 100,000.

AT the annual general meeting of the Middlesbrough branch of the National Union of Clerks Mr. A. J. Hammond, district organiser, said that the N.U.C. had made great progress, and had been successful in obtaining agreements with the most important federations of employers. In the course of the next few days the agreement would be signed with the employers in the iron and steel trades, and this ought to stimulate the clerks in Middlesbrough.

THE MINISTRY OF MUNITIONS announces that, as from January 1, the Huts and Building Materials Section (D.B.1.c) and the Furniture Section (D.B.1.d) of the Disposal Board have been amalgamated under the control of Captain V. B. Powis, to whom all communications in respect of huts, building material, and timber should in future be addressed at Block "Q," and in respect of furniture and camp equipment at Block "O," Earl's Court Exhibition, S.W.5. Telephone, Hammersmith 2300.

SPEAKING at the quarterly meeting of the London Iron and Steel Exchange, Limited, Lord Askwith (president of the British Federation of Iron and Steel, Tin Plate and Metal Merchants) said the merchant represented to the manufacturer, say, from 500 to 1,000 customers, and it was he who searched the world, and, no matter where his customers were—in Central Africa or Patagonia—he supplied them with the goods they required, and when they required them on terms which it would be difficult, and in some cases impossible, for the manufacturer to accept.

A NOTABLE example of the encouraging results which are obtained when masters and men work together in a spirit of goodwill has just been furnished in connection with Cornish tin mining. This industry is suffering from depression consequent upon the fall in the price of tin. The workmen employed by the Tincroft Mines, Limited, Redruth, recognising the difficulties which the directors of the company are faced with have voluntarily offered to contribute £200 per month in order to keep the mines working. In addition they have sent a letter to the directors enclosing copy of a resolution passed by the workmen, in which the latter express gratitude to the directors for keeping the mines going, promise to do their utmost to increase production and end up by wishing the directors "the compliments of the season"

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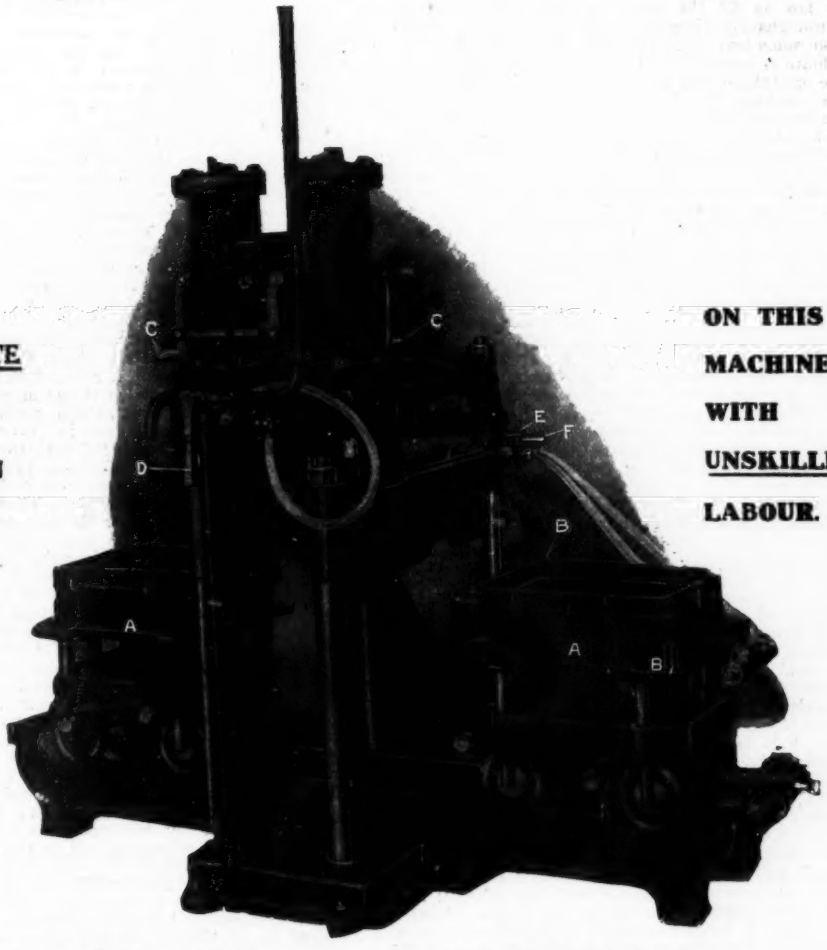


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# IRON AND STEEL MARKETS.

## Pig-Iron.

The effect of the recent arrangement between the Midland ironmasters and coke-oven proprietors, by which fuel costs have been considerably lightened to consumers, has speedily influenced a somewhat drastic revision of pig-iron price lists, a movement initiated by the Cleveland makers last week, and further developed by the almost unanimous action of the chief furnace interests in other districts. This policy was further endorsed at the quarterly meeting of the trade at Birmingham last Thursday, at which, if business was only moderate, some noteworthy reductions in pig-iron prices for Midland brands was an outstanding feature of the proceedings. Some concessions in quotable values had evidently been anticipated in view of the increasingly threatening competition of Belgian furnaces, the latter now being prepared to under-cut the home products, as evidenced by the relatively low prices at which Antwerp shippers are anxious to do business. An illustration of the aggressive nature of our recent Ally's keenness in this direction is evidenced in the fact that Thomas basic pig is on offer at £8 12s., f.o.b., which leaves a substantial margin in its favour after paying transport charges up to £2 per ton, while Belgian No. 3 foundry pig can be bought as low as £7 15s. per ton, f.o.b. Consequently at Birmingham's Thursday market makers of Midland iron submitted a revised list of prices, showing a definite reduction of £1 in Derbyshire forge, making the quotation £11 5s. Derbyshire foundry declined 25s., making No. 3 £11 15s., as compared with the old level of £13, and Derbyshire grey forge at £11 5s., or a reduction of £1 a ton. Northamptonshire forge, which some houses have been asking £12 2s. 6d. for, was down to £11, and lower quotations than this were reported. South Staffordshire prices were irregular. There was a substantial drop of £1 to 25s., forge being offered at £12 5s., and No. 3 foundry at £12 15s., and these are by no means the minimum. In the Cleveland market last week the movement initiated to deflate values has as yet had scarcely any effect in stimulating buying, but an expansion in this direction can hardly be expected in the present conditions of general trade, and it must be well into the spring before there can be a revival of full demand. At all events, even lower figures must then rule before industrial activity can be restored, and until this much-desired result is achieved buying in pig-iron markets will continue of a hand-to-mouth nature. In the existing circumstances stocks are daily accumulating in makers' yards, and in the event of other district prices remaining at higher levels than those in the Tees-side market, the disparity must eventually develop increased buying of Cleveland iron on outside account. Export inquiries continue slow, the deplorable exchange conditions abroad precluding the placing of many foreign orders that would otherwise come to Middlesbrough. It may, however, be reasonably anticipated that the recent reduction in prices of Cleveland iron will ultimately have a beneficial effect upon exports, and already one or two sale transactions are reported with Scandinavian consumers. Prices of Cleveland iron may be repeated as follow:—No. 1 Cleveland, home 225s., export 245s.; Silicious iron, home 225s., export 245s.; No. 3 Cleveland G.M.B., home 215s., export 235s.; No. 4 foundry, home 214s., export 229s.; No. 4 forge, home 212s. 6d., export 217s. 6d.; mottled, home 212s. 6d., export 217s. 6d.; white, home 210s., export 215s.; hematite East Coast mixed numbers, home 240s., export 245s.; No. 1, home 242s. 6d., export 247s. 6d. It will be seen that even with the fall in Midland iron prices Cleveland iron is still very much cheaper, and this will no doubt exert an important influence in favour of local industry. The supply of industrial fuel is now abundant, but there is no indication of any weakening in the price of Durham coke, ordinary blast-furnace qualities being still quoted 62s. 9d. per ton at the ovens, and qualities low in phosphorus 65s. 3d. per ton. The total production of pig-iron, which, owing to the coal strike, fell from 741,000 tons in September to 533,200 tons in October and 403,200 tons in November, rose in December to 675,300 tons, making the total production for the year 8,900,700 tons, compared with 7,398,000 tons for 1919. At Sheffield the reduction of 10s. 9d. per ton in blast-furnace coke has been followed by reductions in pig-iron and steel. Lincolnshire pig-iron and foundry pig-iron have dropped 30s. per ton from £13 to £11 10s., and forge qualities 25s. per ton from £12 5s. to £11. In the Lancashire trade a general reduction all-round in pig-iron prices has naturally followed, sellers now asking for No. 3 foundry iron £11 15s. on trucks, which amounts to about £12 5s. delivered in Manchester, or £12 7s. 6d. in some cases. This is a drop of 45s. from the highest prices, but it is not enough to satisfy buyers in comparison with Cleveland iron now quoted at £10 15s. on trucks, consequently pig-iron business in Manchester does not seem to be any more active as a result of the fall in the nominal prices. It is hoped that a little more buying will be done for a week or two, because some of those who have held off the market for the last two months must be working through their stocks.

## Ore.

On the North-East Coast the stagnation in the foreign ore trade continues unabated. New business is almost impossible, and both prices and freights are drooping, the current c.i.f. quotation for best rubio ore being no more than 45s. per ton in the Tees. Deliveries to date this month are approximately double those for the corresponding period of December. All the iron ore mines in the Furness district closed down last week owing to the slump in the iron trade. This is in consequence of the unsettled conditions in the local iron industry and the lessened demand for ore. Native ores are still quoted 59s. to 70s. per ton net at mines. Spanish and North African ores are being imported and delivered at furnaces at 50s. per ton.

## Steel.

Without expressing too pessimistic a view, it must certainly be admitted that the outlook in the British steel trade at the moment is far from satisfactory, and with order books practically depleted makers may be fully excused for taking a gloomy view of the future prospects of the industry. The explanation of these depressing conditions may be found, it is feared, in the total inability on the part of home and overseas consumers to pay the prices now asked by English steel manufacturers, the restriction of credits and the erratic course of foreign exchanges being important contributory factors in the present slump. The position has also been largely aggravated by the severity of foreign competition, the imports of steel and semi-products, according to the Board of Trade returns for last year, amounting to the very substantial total of 251,202 tons, the bulk coming from Belgium and the United States, with smaller quantities from other countries. While imports of steel material have been steadily growing, the loss in home production is reflected in the December returns of exports of iron, steel and manufactures thereof. The total trade in this section reached 190,392 tons, compared with 237,672 tons in November. Railway material dropped from 32,085 tons to 21,501 tons, galvanised sheets from 22,000 tons to 15,000 tons, and steel bars, rods, and sections from 25,220 tons to 19,780 tons. The last figures, however, exceed those for December, 1913. Production in the Sheffield steel industry has experienced a severe check, most of the furnaces having been idle since the holidays, while the stagnation in the lighter branches is more acute than ever. The trade in high-speed steel is also at a standstill, and it is small comfort to hear that similar conditions apply in this particular department in the States. Perhaps the most hopeful feature in the position is supplied in a fair demand for heavy steel, of which there is a certain amount of buying, while there are also some substantial orders in hand for railway material in the form of axles, tyres, and springs. Another source of business for Sheffield manufacturers has also failed, the Lincoln foundries, hitherto among Sheffield best customers, having few orders this season for agricultural implements and machinery, owing to the destruction of that staple industry of Russia and Eastern Europe by the war. During the month of November there were produced in the Sheffield district 19,000 tons of open-hearth acid steel, 19,000 tons of open-hearth basic steel, 6,300 tons of Bessemer basic steel, 9,200 tons of Bessemer acid steel, and 4,000 tons of other ingots and castings, the grand total exceeding 58,000 tons. The production of pig-iron in the same area was 14,000 tons, mostly basic quality. At Glasgow the depression in the steel trade has been further demonstrated by another decline in prices of black sheets by Scottish manufacturers. The cut, which amounts to £2 per ton, is designed, of course, to secure a much-needed increase in orders, and is the fourth reduction intimated since the decline in trade started some months ago. The price of 3-16-in. to ¼-in. sheets, which opened in 1920 at £28 per ton, reached its highest level of £38 10s. per ton in May. The slackening off of demand necessitated subsequent reductions of £2 in October, £4 in November, and £3 10s. in December. This latest fall of £2 brings the price down to £27, or, allowing for the fact that delivery is now given in Glasgow, about £12 per ton below the maximum point touched last year. At Barrow there is complete idleness in the producing plant and also the mills and foundries.

# SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

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Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.
CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.

*Established 1872.* *Telegraphic Address: "Steel, Glasgow."*

## BAXTER'S

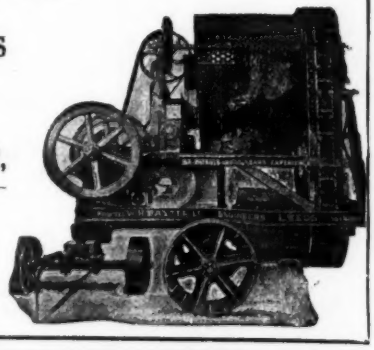
**Patent Knapping Motion**

**STONE BREAKERS**

UNEQUALLED.

*Sole Makers:*

**W. H. BAXTER, LTD., LEEDS**



## SILICA BRICKS,

GROUND GANISTER,

STEEL MOULDERS' COMPOSITION.

PICKFORD, HOLLAND & CO., LTD., SHEFFIELD.

## DAVID COLVILLE

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Dalzell Steel and Iron Works, MOTHERWELL.

Head Office: MOTHERWELL.

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In Soft, Mild, Medium, High Tensile, H H Tensile, Nickel and Alloy Steel.

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## JOHN WILKES, SONS & MAPPLEBECK, LTD

*SEAMLESS and BRAZED BRASS and COPPER TUBES*

Brass and Copper Wire, Rolled Metals, etc. BIRMINGHAM.

## O. GOSSELL & SON, LTD.,

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SPECIALITIES:—

RAILS, TRAM RAILS, STEEL SLEEPERS, STEEL JOISTS to 24 in. deep. CHANNELS, ANGLES, BARS, SHEARED PLATES, FLITCH PLATES to 36 in wide, &c.

BRIDGEWORK and CONSTRUCTIONAL IRONWORK.
SPECIAL STEEL CASTINGS. ROLLING STOCK.

Telephone No.:—CITY 6754. Telegraphic Address:—"GOSSOTTO, LONDON."

## Tinplates.

Reports from South Wales agree as to a general slowing down of production in the tinplate trade; indeed, it is estimated that fully half of the mills are idle, and that about 10,000 men are out. Some districts, however, are better situated than others, Morriston, for instance, not being so badly off as Llanelly, but there is practically an entire absence of orders, the causes of the existing depression being the depleted financial resources of the Continent and the world generally, combined with the consequent abnormally high rate of exchange. The market consequently continues very quiet, but incidentally the tone, as concerns Welsh makes, is firmer as a result, it is said, of the closing down of so many works, and the belief that restricted output is bound to have its effect upon prices. In the view of some makers, nothing less than an all-round improvement in financial conditions abroad will induce Continental buying. At the same time there are more inquiries about, and the price of tinplates is from 33s. to 34s. per basis box, or a shilling better than previous quotations. Makers are holding out for still higher values, and assert that current rates fall fully 4s. per box below the cost of production. Current prices of tinplates are: Cokes, 20 x 14, 33s. to 36s.; quarters, 35s. 6d. to 38s.; cokes, 20 x 10, 48s. to 50s.; ditto, 28 x 20, 66s. to 72s.; ternes, 74s. to 76s.

## Finished Iron.

In common with all other sections of the iron trade, manufacturers of finished material are experiencing a quiet time, and even the most favourably circumstanced are confronted with a position which presents a most difficult problem. Briefly summarised, the situation may be described as a contest between declining demand and the ruling high prices now current for all descriptions of finished iron, the latter inevitable when regarded from the standpoint of excessive costs of production. This, in the face of increasing outside competition, augments the difficulties of manufacturers, who, if even suggesting a substantial lowering of the high wage rates now in force, would at once arouse the antagonism of organised labour, with results disastrous to any prospect of revived demand. That makers of marked bars have already set an example in reducing the price of standard marked brands from £33 10s. to £31 10s. is admitted, but as this section of the trade is perhaps the only one favourably placed for orders, the concession can have very little effect upon business in a general way. But apart from this instance, there is a consensus of opinion among buyers that bars as well as other descriptions of finished material must be further reduced if our home manufacturers are to hold their own, and it was even considered probable that last week's quarterly meeting might develop some movement in that much-desired direction. At present unmarked bars at £28 10s. are quoted much above the prices at which Belgium can supply, and though the latter quality material is only suitable for certain classes of production, such as nuts and bolts, the total quantity imported is by no means negligible in importance to the home producer. In addition it may be noted that, according to the Board of Trade returns issued recently, our energetic Allies are also supplying a by no means unimportant proportion of other manufactures in a substantial tonnage of tubes, pipes and fittings. In the meantime evidence of growing depression in this industry is indicated in the unusually extended holidays taken by the trade, many of the works not having started until last week, and then commencing on depleted order sheets. The one bright feature in the position may be suggested in gas strip, which continues to command a large and steady sale, due to the strong demand for tubes and pipes—a branch necessarily neglected during the war-time period. Prices for this material still rule strong, with the result that we have the anomaly of seeing strip quoted on a higher level than marked bars. Beyond the South Staffordshire area there is little fresh to report in other markets for finished material, business everywhere being on the quiet side.

## Refractories.

The demand for ganister and crucible-making clays amongst the Sheffield crucible steel makers, and also to some extent the demand for refractories by makers of electric steel in Sheffield, has certainly fallen off very considerably on account of the depressed state of these departments of the steel trade, though there are signs of a revival.

It has been reported that Austrian or Hungarian magnesite bricks have arrived in this country, and Austrian magnesite is entering freely. Belgian and French moulding sands and furnace-bottom sands are now also coming in, though by far the greater number of users of these materials have made up their minds to stick to the British sources of supply which were opened out during the war, and which so effectively filled the gap caused by the absence of foreign supplies.

The following are approximate net prices of the principle refractories:—

*Best Silica Bricks* (special quality).—£19 per 1,000, delivered U.K.

*Ordinary Quality Silica Bricks.*—£15 10s. 6d. per 1,000, free on rails makers' works.

*Firebricks* (best Scotch).—£12 15s. per 1,000, free on rails makers' works.

*Firebricks* (best Sheffield quality).—£11 per 1,000, free on rails Sheffield.

*Firebricks* (common).—About £10 per 1,000 delivered U.K.

*Magnesite Bricks.*—£137 10s. per 1,000, delivered U.K.

The above are for 2½-in. bricks, the 3-in. sizes being one-fifth more as a rule.

*Dolomite* (basic).—78s. per ton, free on rails makers' works.

*Magnesite* (dead burnt).—Peas and powder, £26 per ton (in bags), delivered U.K.

*Steel Moulders' Composition.*—Moulding sand and silica sands are quoted delivered, but the prices vary too much in different districts for inclusion here.

*Fireclay* (ground) varies with quality, 30s. to 40s. per ton, free on rails makers' works.

*Ganister.*—Cupolas, ladles, converters and similar purposes from 30s. to 32s. 6d. per ton, free on rails makers' works, according to quality, but an advance will probably be necessary to meet the increase in miners' wages, there being little profit in present figures.

The demand for refractories generally, despite the slackness in the heavy steel trade, continues fairly good, the reason being that many of the works which have set down are utilising the opportunity to make extensive repairs.

Magnesite bricks are specially in demand, though the request for chrome bricks has fallen off very considerably.

The demand for basic dolomite, which is dependent on the actual working of the furnaces, is slack, but refractory manufacturers generally are hopeful of an early revival, and few of them have yet put their works on short time.

## Scrap.

At Middlesbrough the scrap iron and steel market continues very quiet, and no real buying movement has yet commenced. Prices are now quoted at approximately the following figures:—Heavy steel scrap, £7; steel turnings, £6 5s.; borings, £6 5s.; heavy wrought-iron piling, £8 5s.; bundling scrap, £7 15s.; cast-iron scrap, £10 to £10 10s., according to quality—all delivered works. In South Wales the scrap market is lifeless, with ample supplies available. Prices:—Heavy steel scrap, £5 10s. to £7 10s., bundled steel scrap and shearings, £5 10s. to £7; mixed iron and steel scrap for basic furnaces, £2 to £6; heavy cast-iron scrap, £8; and good machinery scrap for foundry purposes, £10 10s. There has developed a weaker tone at Manchester in cast scrap iron, owing to the fall in foundry pig, dealers now asking £10 per ton for the best qualities of cast scrap, but they are obliged to sell their heavy wrought scrap at £6 per ton. The price to which steel turnings has fallen is now £3 10s. per ton.

## Metals.

**Copper.**—Closing last week with some weakness, the standard market opened on Monday with a distinctly easier tone, with business transacted at a loss on forward metal, sellers offering freely. Values further weakened, the close showing a net decline of 20s. both on prompt and forward account. Closing prices:—*Cash*: Wednesday, £74; Thursday, £73 17s. 6d.; Friday, £73; Monday, £74; Tuesday, £70 7s. 6d. *Three Months*: Wednesday, £73 15s.; Thursday, £73 12s. 6d.; Friday, £72 15s.; Monday, £71 15s.; Tuesday, £70 7s. 6d.

**Tin.**—Some realisations imparted a weaker tendency in the week's opening market, while business in the East was impracticable at current rates. A further discouraging feature of the market was the slump in the tinplate trade, and values again receded, closing at the lowest level touched since 1917. There was, however, a fairly active business passing for cash and a good turnover was recorded, English ingots closing lower at £187 to £188. Closing prices:—*Cash*: Wednesday, £205; Thursday, £205; Friday, £200; Monday, £191; Tuesday, £180 10s. *Three months*: Wednesday, £210 15s.; Thursday, £211; Friday, £200; Monday, £191; Tuesday, £185 10s.

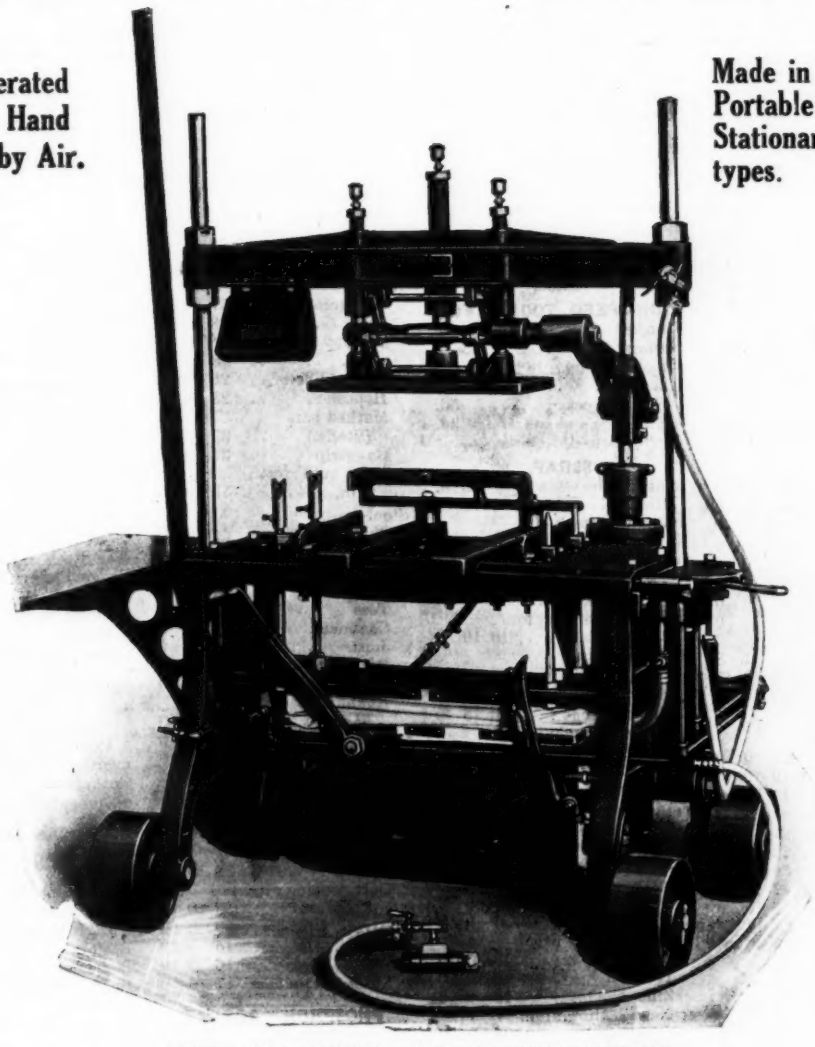
**Spelter.**—The market opened with a quiet tone, with business throughout on a restricted scale, the tendency showing an easier tone, near rates declining 7s. 6d. and forward 3s., closing ordinary brands prompt £24, with English nominal £27.

**Lead.**—The market was easier with only a limited business transacted, prices ruling lower, closing 7s. 6d. to 5s. lower, with soft foreign prompt at £22 17s. 6d. and English 10s. lower at £25.

# BERKSHIRE MOULDING MACHINE

**Operated by Hand or by Air.**

**Made in both Portable and Stationary types.**



MODEL "E" PORTABLE AIR SQUEEZER—COMPLETE.

1. It uses either Split Patterns or Match Plates.
2. It squeezes all Moulds exactly alike, regardless of air pressure.
3. Cope rolls back out of the way. Cores are set and Mould closed right on machine, without lifting off Cope.
4. It makes quick changes possible, from one style pattern to another.
5. It is quickly adjusted to different size Flasks.
6. It is equipped with "Berkshire" pneumatic Vibrators for any style Pattern.
7. Pattern Drawing Device so simplifies its operation that unskilled labour can easily draw the most difficult pattern.
8. It can be operated by hand as well as by air.

## JOHN MACDONALD & CO.,

*Pneumatic Engineers,*

## POLLOKSHAWS, GLASGOW.

Telegrams: "Consulting, Pollokshaws." Telephone: 27 Pollokshaws.

# WEEKLY PRICE CURRENT.

## COPPER.

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 70 | 7 | 6 |
| Three months | 70 | 7 | 6 |
| Electrolytic | 82 | 0 | 0 |
| Tough | 79 | 0 | 0 |
| Best selected | 79 | 0 | 0 |
| Sheets | 130 | 0 | 0 |
| India | 130 | 0 | 0 |
| Wire bars | 82 | 10 | 0 |
| Do. Jan. | 82 | 10 | 0 |
| Do. Feb. | 82 | 10 | 0 |
| Ingot bars | 81 | 10 | 0 |
| H.C. wire rods | 91 | 0 | 0 |
| Off. aver. cash, Dec. | 75 | 16 | 8 |
| Do. 3 mths., Dec. | 76 | 3 | 4 |
| Do. Settlement Dec. | 75 | 15 | 2½ |
| Do. Elec., Dec. | 86 | 13 | 6½ |
| Do. B.S., Dec. | 84 | 13 | 4 |
| Aver. spot, copper, Dec. | 75 | 14 | 10¼ |
| Do. Elec., Dec. | 88 | 0 | 5¾ |
| S.D. tubes | | | 17½d. |
| Brazed tubes | | | 17½d. |
| Wire | | | 16½d. |
| Y.M. rods | | | 10d. |
| Do. 4x4 Sqs. | | | 14d. |
| Do. 4x3 Shts. | | | 14d. |

## BRASS.

| | |
|---|---|
| S.D. tubes | 15½d. |
| Brazed tubes | 18½d. |
| Rods | 14½d. |
| Shts. to 10 w.g. | 13½d. |
| Wire | 13½d. |
| Rolled metal | 13½d. |

## TIN.

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 180 | 10 | 0 |
| 3 Months | 185 | 10 | 0 |
| English | 195 | 0 | 0 |
| Bars | 197 | 0 | 0 |
| Chinese | 194 | 0 | 0 |
| Straits | 215 | 0 | 0 |
| Australian | 207 | 0 | 0 |
| Eastern | 236 | 0 | 0 |
| Banca | 225 | 0 | 0 |
| Off. aver., cash, Dec. | 212 | 11 | 8 |
| Do. 3 mths., Dec. | 216 | 17 | 1½ |
| Do. Sttlment., Dec. | 212 | 16 | 5½ |
| Aver. spot, Dec. | 212 | 7 | 10½ |

## SPELTER.

| | £ | s. | d. |
|---|---|---|---|
| Ordinary | 24 | 0 | 0 |
| Remelted | 19 | 10 | 0 |
| Hard | 17 | 0 | 0 |
| Electro 99.9 | 34 | 0 | 0 |
| English | 27 | 0 | 0 |
| India | 22 | 0 | 0 |
| Prime Western | 26 | 0 | 0 |
| Zinc dust | 62 | 10 | 0 |
| Zinc ashes | 6 | 10 | 0 |
| Off. aver., Dec. | 28 | 11 | 6½ |
| Aver., spot, Dec. | 26 | 9 | 0 |

## LEAD.

| | £ | s. | d. |
|---|---|---|---|
| Soft forgn. ppt. | 22 | 17 | 6 |
| English | 25 | 10 | 0 |
| Off. aver., Dec. | 24 | 11 | 10½ |
| Aver. spot, Dec. | 17 | 19 | 0 |

## ZINC SHEETS.

| | | | |
|---|---|---|---|
| Zinc sheets, spot | 42 | 10 | 0 |
| Do. V.M. ex. whf. | 44 | 0 | 0 |
| Do. ppt., f.o.b., N.Y. | | | — |
| Do. c.i.f. | | | — |
| Boiler plates | 39 | 10 | 0 |
| Battery plates | 40 | 10 | 0 |

## ANTIMONY.

| | | | |
|---|---|---|---|
| Eng. regulus | 40 | 0 | 0 |
| Spec. brands | 42 | 0 | 0 |
| Chinese | 25 | 0 | 0 |
| Crude | 23 | 0 | 0 |

## QUICKSILVER.

| | | | |
|---|---|---|---|
| Quicksilver | 12 | 10 | 0 |

## FERRO-ALLOYS AND STEEL-MAKING METALS.

| | | | |
|---|---|---|---|
| Ferro-silicon— | | | |
| 45/50% | 19 | 10 | 0 |
| 75% | 20 | 10 | 0 |
| Ferro-vanadium— | | | |
| 35/40% | 32/6 lb. va. | | |
| Ferro-molybdenum— | | | |
| 70/80% | 7/9 lb. mo. | | |
| Ferro-Titanium— | | | |
| 23/25%, carbonless | 1/6 lb. | | |
| Ferro-phosphorus, 20/23%, | £49 | | |
| Ferro-tungsten— | | | |
| 80/85%, carbon low | 2/5 lb. | | |
| Tungsten metal powder— | | | |
| 98/99% | 3/1 lb. | | |
| Ferro-chrome— | | | |
| 4/6% car. | £37 | 10 | |
| 6/8% car. | £37 | | |
| 8/10% car. | £36 | 10 | |
| Ferro-chrome— | | | |
| Max. 2% car. | £88 | | |
| Max. 1% car. | £106 | | |
| Max. 0.75% car. | £123 | | |
| 65/75%, carbonless | 3/- lb. | | |
| Nickel—98/99%, cubes or pellets | £215 | | |
| Cobalt metal—97% | 20/- lb. | | |
| Aluminium—98/99% | £165 | | |
| Metallic Chromium— | | | |
| 98/99% | 7/6 lb. | | |
| Ferro-manganese— | | | |
| 76/80%, loose | £32 | | |
| 76/80%, packed | £33 | | |
| 76/80%, export | £33 | | |
| Metallic manganese— | | | |
| 98/99%, carbonless | 3/6 lb. | | |

Per ton unless otherwise stated.

## HIGH-SPEED TOOL STEEL.

| | | | |
|---|---|---|---|
| Finished bars, 14% tungsten | 3 | 2 | |
| Finished bars, 18% tungsten | 4 | 0 | |
| Scrap pieces | 5d. | | |
| Turnings and swarf | 3d. | | |

Per lb. net, d/d works.

## SCRAP.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| South Wales— | | | | | | |
| Heavy Steel | 5 | 10 | 0 | 7 | 10 | 0 |
| Bundled steel & shearings | 5 | 10 | 0 | 7 | 0 | 0 |
| Mixed iron & steel | 2 | 0 | 0 | 6 | 0 | 0 |
| Heavy cast iron | | 8 | 0 | | | 0 |
| Good machinery for foundries | | 10 | 10 | | | 0 |
| Cleveland— | | | | | | |
| Heavy steel | | 7 | 0 | | | 0 |
| Steel turnings | | 6 | 5 | | | 0 |
| Steel borings | | 6 | 5 | | | 0 |
| Heavy wrought iron piling | | 8 | 5 | | | 0 |
| Bundling scrap | | 7 | 15 | | | 0 |
| Cast-iron scrap | | 10 | 5 | | | 0 |
| Lancashire— | | | | | | |
| Cast iron scrap | | 10 | 0 | | | 0 |
| Heavy wrought | | 6 | 0 | | | 0 |
| Steel turnings | | 3 | 10 | | | 0 |
| London— | | | | | | |
| Copper (clean) | | 58 | 0 | | | 0 |
| Brass (clean) | | 37 | 0 | | | 0 |
| Lead (less usual draft) | | 18 | 0 | | | 0 |
| Tea lead | | 16 | 0 | | | 0 |
| Zinc | | 13 | 0 | | | 0 |
| New aluminium cuttings | | 105 | 0 | | | 0 |
| Braziery copper | | 48 | 0 | | | 0 |
| Gun metal | | 56 | 0 | | | 0 |
| Hollow pewter | | 125 | 0 | | | 0 |
| Shaped black pewter | | 75 | 0 | | | 0 |

## PIG-IRON.

| | |
|---|---|
| N.-E. Coast— | |
| Foundry No. 1 | 225/- |
| Foundry No. 3 | 215/- |
| Forge No. 4 | 212/6 |
| Mottled | 212/6 |
| Hematite No. 1 | 242/6 |
| Hematite M/Nos. | 240/- |
| Midlands— | |
| Staffs. common | 205/- |
| ,, part-mine forge | 245/- |
| ,, ,, foundry | 255/- |
| ,, Cold blast | 385/- |
| ,, basic | 237/6 |
| Northants forge | 217/6 |
| ,, foundry No. 3 | 230/- |
| ,, basic | 230/- |
| Derbyshire forge | 225/- |
| ,, foundry No. 3 | 235/- |
| ,, basic | 245/- |
| Scotland— | |
| Foundry No. 1 | 275/- |
| ,, No. 3 | 265/- |
| Hematite M/Nos. | 250/- |
| Sheffield— | |
| Derby forge | 220/- |
| ,, foundry No. 3 | 230/- |
| ,, basic | 240/- |
| Lincs. forge | 220/- |
| ,, foundry No. 3 | 230/- |
| ,, basic | 240/- |
| E.C. hematite | 250/- |
| W.C. hematite | 290/- |

All d/d in the district.

| | |
|---|---|
| Lancashire— | |
| Derby forge | 220/- |
| ,, foundry No. 3 | 245/- |
| Northants foundry No. 3 | 245/- |
| Cleveland foundry No. 3 | — |
| Staffs. foundry No. 3 | — |
| Lincs. forge | — |
| ,, foundry No. 3 | — |
| Summerlee foundry | 300/- |
| Glengarnock foundry | 300/- |
| Gartsherrie foundry | 300/- |
| Monkland foundry | 300/- |

## FINISHED IRON & STEEL.

| | £ | s. | d. |
|---|---|---|---|
| Iron— | | | |
| Bars (crown) | 27 | 10 | 0 |
| Angles | 28 | 0 | 0 |
| Tees to 3 united ins. | 28 | 10 | 0 |
| Nut and bolt | 26 | 0 | 0 |
| Hoops | 28 | 10 | 0 |
| Marked bars (Staffs.) | 33 | 10 | 0 |
| Gas strip | 32 | 10 | 0 |
| Bolts and nuts, ⅜ in. × 4 in. | 51 | 0 | 0 |
| Steel— | | | |
| Ship plates | 24 | 10 | 0 |
| Boiler plates | 31 | 0 | 0 |
| Checquer plates | 30 | 0 | 0 |
| Angles | 24 | 0 | 0 |
| Tees | 25 | 0 | 0 |
| Channels | 25 | 15 | 0 |
| Joists | 24 | 0 | 0 |
| Rounds, ½ in.–3-in. | 24 | 10 | 0 |
| Rounds, 3 in.–5½ in. | 23 | 10 | 0 |
| Flats, 5 in.–8 in. | 25 | 0 | 0 |
| Flats over 8 in. | 24 | 10 | 0 |
| Rails, heavy | 25 | 0 | 0 |
| Fishplates | 30 | 0 | 0 |
| Hoops | 28 | 10 | 0 |
| Black sheets, 24 g. | 27 | 10 | 0 |
| Galv. cor. sheets, 24 g. | 28 | 10 | 0 |
| Galv. fencing wire, 8 g. plain | 38 | 10 | 0 |
| Rivets, ½ in. dia | 39 | 0 | 0 |
| Billets, soft | 15 | 0 | 0 |
| Billets, hard | 16 | 0 | 0 |
| Sheet and tin bars | 17 | 0 | 0 |

## PHOSPHOR BRONZE.

| Rolled. | Per lb. s. d. |
|---|---|
| ⅛ in. to 1 in. wide | 2 1½ |
| 1 in. to 1½ in. wide | 2 0½ |
| 1½ in. to 2 in. wide | 1 11½ |
| **Strips.** | s. d. |
| 2 in. to 6 in. to 26 S.W.G. | 1 10½ |
| 6 in. to 12 in. to 26 S.W.G. | 1 10½ |
| **Sheets.** | s. d. |
| 12 in. to 18 in. to 24 S.W.G. | 1 11 |
| 18 in. to 24 in. to 24 S.W.G. | 1 11½ |
| 24 in. to 30 in. to 20 S.W.G. | 2 0½ |
| 30 in. to 36 in. to 16 S.W.G. | 2 1½ |
| 36 in. to 42 in. to 16 S.W.G. | 2 2½ |

**Extras.**

For Gauge: Any width up to 36 in. wide, ½d. per lb. per thinner gauge.

| Drawn Rods. | s. d. |
|---|---|
| ⅛ in. to ½ in. dia. in random lengths | 1 11½ |
| 9/16 in. to 1½ in. dia. in random lengths | 1 11½ |
| Over 1½ in. to 1⅝ in. | 1 11½ |
| Tubes—basis price | 2 1½ |

Delivery 2 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

Charles Clifford & Son, Limited, Birmingham.

## NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

| | Per lb. |
|---|---|
| Ingots for raising | 1/3 to 1/9 |
| Rolled— | |
| To 9 in. wide | 1/10½ to 2/4½ |
| To 12 in. wide | 1/11 to 2/5 |
| To 15 in. wide | 2/- to 2/6 |
| To 18 in. wide | 2/1 to 2/7 |
| To 21 in. wide | 2/2 to 2/8 |
| To 24 in. wide | 2/3 to 2/9 |
| Ingots for spoons and forks | 1/3 to 1/9 |
| Ingots rolled to spoon size | 1/6 to 2/- |
| Wire round— | |
| 3/0 to 10. G. | 2/1 to 2/8 |

with extras according to gauge.

## SWEDISH IRON.

F.O.B. Gothenburg net cash.

| | £ | s. | d. |
|---|---|---|---|
| Bars, hammered basis sizes | Basis price. | | |
| Rolled Ordinary— Assortment | 33 | 0 | 0 |
| Nail Rods— Square, round and flats | 33 to 40 | 0 | 0 |
| Keg Steel } about Faggot Steel } £50 | Prices nominal. | | |

Blooms—

Single welded .. £20 to £25

Billets—

Single and double welded .. £22 to £27

Pig-Iron—

Grey, white or mottled .. £15 to £20

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

## AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.

| | Dols. |
|---|---|
| No. 2X foundry, Phila. | 33.79 |
| No. 2 foundry Valley | 33.00 |
| No. 2 foundry, Birm. | 36.00 |
| Basic | 31.96 |
| Bessemer | 33.96 |
| Malleable | 35.96 |
| Grey forge | 34.96 |
| Ferro-manganese, Atl. port | 110.00 |
| Bess. rails, h'y, at mill | 45.00 |
| O.-h. rails, h'y, at mill | 47.00 |
| Bess. billets | 43.50 |
| O.-h. billets | 43.50 |
| O.-h. sheet bars | 47.00 |
| Wire rods | 57.00 |
| | Cents. |
| Iron bars | 3.50 |
| Steel bars | 2.35 |
| Tank plates | 2.65 |
| Beams, etc. | 2.45 |
| Skelp, grooved steel | 2.65 |
| Skelp, sheared steel | 2.65 |
| Steel hoops | 3.05 |
| Sheets, black, No. 28 | 4.35 |
| Sheets, galv., No. 28 | 5.70 |
| Sheets, blue an'l'd, 9&10 | 3.55 |
| Wire nails | 3.25 |
| Plain wire | 3.25 |
| Barbed wire, galv. | 4.10 |
| Tinplate, 100-lb. box | $7.00 |

## COKE.

| | |
|---|---|
| Welsh foundry | 72/6 |
| ,, furnace | 55/- |
| Durham & North foundry | 70/- |
| ,, furnace | 62/9 |
| Other Districts, foundry | 77/9 |
| ,, furnace | 55/- |